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SCIENCE EDUCATION

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CONDITIONS WHICH CORRELATE WITH THE PRODUCTION OF AMERICAN LEADERS

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SCIENCE teachers are largely concerned with the facts of the science which they teach and in methods of more effective teaching. However they are necessarily also deeply interested in how to aid their more promising students to rise to the highest level to which they are qualified. Hence they welcome information on successful people of various sorts. As almost everyone now realizes, persons who win the opportunity to be leaders are especially successful in significant respects. Indeed, wise leadership is a prime requisite of civilization. Only with competent leaders can civilization advance, can a democracy successfully withstand the attacks of ruthless dictators.

It therefore becomes worthwhile for teachers of science to learn what they can learn without too much effort as to what has been discovered by those who have carried out extended research on what conditions are conducive to the development of highly productive people, leaders.

What conditions facilitate human productivity and what conditions retard? To find the answers requires much earnest study. The present writer has worked on aspects of this problem for many years, especially concerning scientific leaders, scientists starred in "American Men of Science" by the secret ballot of their fellow workers as especially distinguished in research. Also studied intently have been people sketched in "Who's Who in America".

Detail findings are presented as articles in several scholarly journals and in three volumes, the first of which was published by Indiana University (in 1928), the second by Johns Hopkins University Press (in 1947), and the third, "Indiana Scientists", published by the Indiana Academy of Science (1951).

Leaders, of course, are especially valuable. Indeed various competent men believe that a large share of civilization's progress has been induced by a few outstanding leaders. However the good that a genius can accomplish is vastly augmented by the help of many lesser leaders. Hence also studied have been thousands of men and hundreds of women who have contributed notably without being so outstanding as to have won a place in encyclopedias such as Britannica.

FROM WHERE HAVE THE LEADERS COME?

In brief, of the approximately 20,000 American notables studied, New England produced about twice as many in proportion to its population as did the Middle Atlantic or North Central States, nearly three times as many as did the Pacific States and about six times as many as did the South Central States. A southward decline in the yield of leaders in proportion to the population at their date of birth prevailed not only among the census groups of states, but, with few exceptions, among the individual states.

State yields of starred scientists near the

Mississippi River were, (per million population) Minnesota 120, Wisconsin 83, Iowa 67, Illinois 65, Missouri 32, Tennessee 13, Mississippi 4. Near the Atlantic coast, New England had an average yield of 133 per million, the Middle Atlantic States one of 67, the northern part of the South Atlantic States (South Carolina to Maryland) an average of about 35, and Georgia, Florida and Alabama an average of about 9. Hence these four groups of eastern states display an approximate southward zone-by-zone halving of yield. The southward decline near the Mississippi River is at a roughly comparable rate.

A generalization as to the regional origin of notables justified by the abundant data here summarized is that states that produced few scientists also produced few artists, administrators or other leaders, and vice versa.

POSSIBLE EXPLANATIONS OF THE REGIONAL CONTRASTS

The conspicuous regional differences in the yield of notables may advantageously be considered with our attention focused on contrasts in the environment. First let us consider climate. Ellsworth Huntington believed that a fairly favorable climate is a prerequisite to a high civilization, and hence to the yield of numerous leaders. The southward decline is completely in accord with that theory. It may be partly caused by the selective effects of the winters. The long, cold winters of the more northern states are not at all to the liking of easy-going people, who are numerous in the South. Consequently, although Missouri and Virginia, for example, have yielded many leaders, their contribution to leadership in proportion to population is notably reduced by their large population of "easily satisfied" people. Abundant evidence, however, indicates that although climate may help to explain the general distribution, it is not paramount within the northeastern quarter of the United States. For example, nearby areas with almost identical climates differ greatly in the yield of notables, i.e., the southeastern and southwestern quarters of Indiana, Illinois, and Wisconsin and southern Michigan and northern Indiana, and Rhode Island and Connecticut.

Another often held theory is that "as wealth increases so does yield of leaders". True, many relatively rich areas produced more leaders than did certain poorer ones. Thus in each of the states studied in detail, the areas relatively productive of notables have distinct geographic advantages over certain other areas which are less productive. But various rich areas have not been nearly so productive of leaders as some poorer areas.

Satisfactory estimates of the comparative wealth of different areas are not available partly because there are so many aspects of wealth. Nevertheless, the Census Bureau's estimate of the wealth of the states throws light on this theory. The resulting map of the average wealth per square mile resembles in a general way the map of the yield of notables. But the exceptions clearly suffice to prove that wealth per square mile is not a predominant factor. For instance, the Rocky Mountain States had only about one-third as much wealth as the South Central States, but yielded more than twice as many notables proportionately. When individual states are considered, more striking discrepancies are disclosed. Thus, Louisiana had nearly twice the wealth per square mile but only one-thirtieth the productivity of Maine. Rhode Island has over twice the wealth of Connecticut but less than half the productivity. If instead of the wealth per area, the wealth per capita is considered, even less correlation occurs.

Of the various sorts of wealth, the one most widely thought of as "real wealth," namely mineral wealth, seems indeed to be distinctly unfavorable to the yield of leaders. At any rate, very few were born in the mining communities of America.

The statement of Frederick Jackson

Turner, the eminent historian, that "It often seems to be largely a matter of topography; the level lands yield leaders as well as crops, while the rugged lands produce few of either," led to a special study of the correlation between topography and yield of leaders. In Ohio the area which yielded fewest notables is, indeed, almost the most rugged, but another area which yielded few is almost level and agriculturally highly productive. Moreover, the hilly section of northeastern Ohio yielded many. In Indiana, likewise, the most rugged area yielded few notables, but much smooth land did no better. In Illinois, similarly, a large share of the relatively sterile southern section, containing half of the state's population in 1870, is smoother than much of northern Illinois, the birthplace of many notables. In Wisconsin, the relatively hilly unglaciated section yielded few notables, but smooth areas elsewhere were equally sterile while other hilly areas were productive. In Kentucky the most level, fertile part of the state, at the west, yielded few notables. Thus it seems evident that topography is not a major influence.

Let us next consider state of settlement and density of population. It has often been asserted that frontiers can not be expected to produce leaders as the people are engaged in "hewing homes out of the wilderness". Evidence supporting this theory is the fact that there was in the Midwest an increased yield of leaders in proportion to population from 1860 to 1870 or 1880, and also that the southern halves of the populations of Michigan, Wisconsin and Minnesota yielded many more notables than the northern. Contrary evidence is the declining yield in proportion to population that occurred in the Eastern States, and more recently in various parts of the North Central States. These declines almost disprove this theory.

Moreover, although southern New England was the first American region to pass beyond the agricultural stage, it was in these regards only a little ahead of Pennsylvania, which yielded only one-third as many notables, relatively. Likewise the better lands of the south, from Virginia to Louisiana, attained a relatively high culture long before most of the Midwest did so. In Canada, Quebec, the first province to become populous, ranks lowest in the relative yield. Similarly, densely settled Rhode Island was far excelled by rural Vermont in the yield of notables.

YIELD OF CITY, TOWN AND COUNTRY

It has often been asserted that most famous Americans were born on farms. On the other hand, certain studies of small groups of eminent people have revealed that relatively many were born in cities. In order to throw light on this question a "special request" prepared by the present writer was sent to all persons sketched in one edition of "Who's Who in America" to indicate the type of place in which they were born. Replies from 18,400 persons indicate that approximately equal numbers were born on farms, in villages and towns, in small cities and in large cities or their suburbs. Of 905 starred scientists, 22 percent reported that they lived while young on farms, 15.5 percent lived in rural villages, 31 per cent lived in small cities, 25 percent lived in large cities and 6.5 percent lived in suburbs of or near to large cities.

At the 1870 census, the census nearest to the birth of most of these notables, about one-tenth of the people of the United States lived in cities of over 50,000; one-ninth in cities of 8,000 to 50,000; one-twelfth in small places; and almost seven-tenths on farms.

Thus in proportion to population, cities contributed nearly six times as many notables as did farms; villages nine times as many; and suburbs eleven times as many.

Of the most eminent group of notables, the largest cities yielded many more than their proportionate numbers, the cities of the northeast and their suburbs yielding

more than one-fourth of the total and the large cities of the South almost a half of the few who were born in the South. In the Midwest, however, many of the more eminent notables were born in villages and a considerable number on farms.

Especial note was made as to the relative contribution of county seats and college towns. The average county seat yielded notables at about three times the rate of the rest of the state. Likewise, cities and towns which contained colleges had an average productivity of fully twice that of other cities in their states. Approximately one-third of the many starred scientists born in Ohio and Illinois were born in college towns, more than half of those of Kentucky.

The largest cities of each midwest state did less well than the smaller, and those which grew most rapidly yielded proportionately fewer than other cities in the same state.

Thus it appears that the parents of notables (as might be expected of alert people anxious to better their conditions and possessed of the requisite boldness, energy and resources to do so) gather in the centers of population, as here there are more opportunities to use their skill. In the Midwest, although in 1870 nearly four-fifths of the population was rural, the towns already contained, it appears, a considerable share of the parents of leaders. As opportunities for gaining a livelihood in the towns and cities increased, progressively larger proportions of the most alert, ambitious people moved to the more attractive cities, often the county seats with colleges. But the cities also attracted many manual laborers, so that, in proportion to population, the highly intellectual type commonly forms a smaller percentage, except in choice residential sections and suburbs, than in the smaller county seats. Nevertheless, in the yield of the most outstanding artists, architects, authors and scientists, the large cities led in proportion to population.

HOME ENVIRONMENTS OF NOTABLES

The questionnaire sent to all subjects of sketches in "Who's Who in America" included a request for information as to the occupations of their fathers. The 18,400 replies revealed that business men and professional men each fathered slightly more than a third of the American notables born about 1870, and farmers almost one-fourth. Skilled laborers, however, fathered only a small share, and the vast number of unskilled laborers almost none.

In proportion to their numbers in the general population at the 1870 census, professional men fathered more than twice as many notables as business men, nearly twenty times as many as farmers, about forty-five times as many as skilled laborers, and 1,340 times as many as unskilled laborers. Farmers, on the other hand, fathered one-fourth less than their proportionate share, but contributed more than twice as many as did skilled and semi-skilled laborers and seventy times as many as the nearly one-half of the men of the nation who were classed as unskilled laborers.

Thus, about 1870, only one unskilled laborer in about 38,000 fathered a son or daughter sufficiently noteworthy to win later a place in "Who's Who". One skilled laborer in 1,300 had that distinction, one farmer in 550, one business man in 62, and one professional man in 27.

As previous studies by Cattell, E. L. Clarke, C. M. Cox, Havelock Ellis and others had indicated that many notables were sons of professional men, the questionnaires sent to the persons sketched in "Who's Who in America" and to the living starred scientists requested a classification of their fathers. Those whose fathers were clergymen were asked to state the denomination, and for other professional men, the profession. Exactly one-ninth of the notables reported their fathers as clergymen. In proportion to their numbers, Protestant clergymen contributed four times as many eminent sons as did business men, thirty-

five times as many as did farmers, and 2,400 times as many as did unskilled laborers.

SOME CONCLUSIONS

In conclusion, it is therefore apparent that a small portion of the men of 1870 fathered a large share of the present leaders. Most of these fortunate men belonged to the so-called upper classes.

The proper interpretation of this concentration is in dispute. Advocates of the theory that environmental influences dominate assert that the classes that produced most leaders did so because they had the best opportunities for cultural and physical development. They claim that there are many children of unskilled leaders who are as capable as the children of the upper classes. On the other hand, advocates of the theory that hereditary influences predominate declare that children of unskilled laborers, when adopted into homes of professional men or otherwise given comparable opportunities, nearly always fail to become leaders. They likewise declare that the superior economic status of the fathers of most leaders is the result of their superior qualities of mental alertness, earnestness, ambition and vitality.

Advocates of the theory that social selection is very important find much support in such data as are here summarized. They point out that the mentally alert people are chiefly found in occupations where their mentality is most advantageous, while the mentally dull are chiefly found in occupations calling for physical strength or routine work. Selection of another type is illustrated by immigrants of exceptional ability. These have come from numerous areas; for example, a very considerable number of eminent Americans are of German descent, especially of the liberals who came over following the revolution of 1848. Scotland, both directly and via north Ireland (the Scotch Irish), also has supplied many ancestors of eminent Americans. But according to much evidence, by far the largest group of American leaders are descendants of emigrants from East Anglia, England, the district which, according to Havelock Ellis ("British Genius"), yielded relatively many eminent British and most of the Puritans of New England, the Quakers, and the Cavaliers of Virginia. The westward spread of the descendants of the Puritans out from New England clearly helps explain the geographical contrasts in the yield of notables. Conversely, their partial submergence numerically by less productive stocks largely produced the subsequent decline in the yield of notables in proportion to population in New England and various more western areas.

Areas yield most notables which contain most mentally alert, ambitious, persistent, energetic people possessed of high ideals. Such people seek opportunities to use their abilities; they appreciate congenial associates and therefore congregate in desirable towns and in choice residential districts or suburbs of cities. Since Quakers, Scotch, Germans of 1848 and especially Yankees include many people of this type, many notables were born wherever such stocks formed a relatively large share of the population.

Notable persons are a product of both environment and heredity, certainly not predominantly of one of these. It is essential that certain physical and mental qualifications be contributed by heredity. But numerous persons who possess the biological potentialities of being notables fail to do so because of unfavorable environmental conditions.

Of the many environmental influences which contribute greatly to the development of leaders, some of the most important are those of the home and community. A person receives from his parents and other ancestors influences which affect his development in numerous subtle ways. It is impossible to conclude how much is biological heredity and how much is "social environmental heredity". Much evidence indicates that the family and community

influences combined are vitally important. Hence, in order to increase the number of creatively productive people, there should be an increase in the number of children born and reared in families potentially able to contribute superior qualities both genetically and culturally. One of the ways of bringing about such an increase is to make it more widely realized that such homes are vitally important and that decadence is inevitable if the rearing of the next generation of children is left largely to those who are not well qualified both biologically and culturally.

The yield of notables generally correlates with local economic and social conditions. For example Odin found that the geographically favored lowland Paris Basin was the birthplace of most French artists, not one of whom during three centuries was born in the scenic French Alps. Likewise the exceptionally fertile Nashville Basin of Tennessee has been the birthplace of most of the notables born in Tennessee.

Similarly, much evidence supports Ellsworth Huntington's conclusion that a climate favorable to the stage of culture thus far achieved at any given time and place is almost a prerequisite to a high civilization, and hence to the production of many notables. However, detailed studies here summarized strongly indicate that the physical or geographic environmental influences in as favored a land as America often operate in affecting the concentration of certain types of people rather than directly by affecting diet, occupation, health and energy. A region relatively poor in resources or climate usually comes, in time, to be peopled largely with those who are relatively lacking in ambition; the more favored areas attract people possessing relatively large amounts of resourcefulness and energy. In the United States, two of these more favored areas are the educational and political centers and the suburbs or choice residential sections of prosperous cities. Notables and their parents are exceptionally mobile, and alert to better their opportunities.

Most of the leaders queried reported that a teacher had much influence upon their development and subsequent achievement.

The great influence of encouragement as a factor in the lives of notables indicates that increased efforts should be made to encourage. Hence, able, earnest people should receive greater public recognition and increased opportunities for training and employment.

Finally, three things all of us should do are: 1) Encourage our promising students and friends to prepare themselves for and undertake leadership. 2) Encourage and aid in every way we can those who are now leaders and, 3) Do our best to increase the number of children reared by parents that are well qualified biologically and culturally to rear future leaders. There obviously is dire need already for better comprehension, broader vision, more willingness to serve unselfishly and more stamina. Very few people with these qualities come from families that are poorly qualified biologically and culturally.

TEACHING CHEMISTRY FOR SCIENTIFIC METHOD AND ATTITUDE DEVELOPMENT *

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Teachers of science have wholeheartedly accepted this truly significant objective: the student should know and be able to use the methods of science in the solution of problems and display an accompanying scientific attitude. This acceptance, however, has not necessarily meant that anything constructive is being done in science classes to assure attainment of this objective by the students. Instead, there has been a feeling or a hope that the typical pattern of teaching and materials in science courses is sufficient to bring about the desired results. Research findings indicate that possession of a scientific attitude and the ability to use the methods of science on the part of students are not natural consequences of being a member of a science class.[1] (1, 2)

It is reasonable to assume that acquiring ability to use the methods of science can best be accomplished through allowing, or, better still, requiring the students to practice the use of them. It follows that the best place for such practice is in the laboratory phase of science teaching. Must it be assumed, however, that the commonly found deductive-descriptive laboratory exercises are the best we have in laboratory instruction for our purposes? Thelen (3) gathered evidence to the contrary for courses at the first year level in college.

The study reported here (4) was designed to give some measure of the effectiveness of a program of secondary school chemistry teaching which included in its operation the use of an inductive-deductive approach to provide an opportunity for students to apply and practice the use of methods of science. Specifically, the purpose of this study was to compare through experimental evaluation the learning of students instructed in such a manner as to stress the inductive-deductive approach with the learning of students instructed through the use of the more commonly found deductive-descriptive approach in the laboratory as it contributes to the objectives of high school chemistry.

Comparisons were made with respect to the relative attainment of each of four specific objectives and the total achievement involving all of these four:

1. knowledge of basic facts and principles of chemistry
2. application of the principles of chemistry to new situations
3. knowledge of and ability to use the scientific method with an accompanying scientific attitude
4. ability to perform in the laboratory with resourcefulness using sound techniques.

The experiment was carried out using two classes selected at random from the 1948–1949 chemistry enrollment at the University of Minnesota High School. In addition to this self-contained experiment, seven classes were selected by randomization techniques from schools of Minnesota having approximately the same enrollment. Classes ranged in size from 19 to 30 pupils. Each class was randomly assigned to take part in the evaluations involving some one of the objectives. These additional classes were taught in the manner their respective teachers commonly used. The techniques used and the materials taught in the courses

* Based on a thesis submitted to the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1950. Paper presented at the Twenty-fifth Annual Meeting of the National Association for Research in Science Teaching, Congress Hotel, Chicago, Illinois, February 14, 1952.

[1] It is not possible to include here the comprehensive review of the literature to be found in the original study. References (1) and (2) are representative.

of chemistry were essentially the same as those used in the University High School deductive-descriptive, control, class. This was ascertained by class visitation, teacher interview, and analyses of the textbooks and laboratory manuals used in the various classes.

Teaching in the class following the inductive-deductive approach in University High School differed from that using the deductive-descriptive approach essentially in the laboratory phases. In the inductive-deductive teaching, the laboratory was used to obtain data to be used in the solution of a problem the students had a real desire to solve. The problem was used to introduce a general principle of chemistry. The mode of attack was pupil planned with teacher guidance. The data were used to draw conclusions which were in the form of a general principle whenever possible. Teaching progressed from the particular to the general. The pupils were encouraged to recognize the value of controlled experiments, the assumptions which were basic to the laboratory plans, the desirability of clear and easy to use records, the necessity for using good laboratory techniques and careful observations, and the limitations of the data collected for drawing conclusions. In the class periods following the laboratory work the generalization was applied to numerous other related problems.

In the deductive-descriptive teaching, the laboratory exercises were taken from a representative published laboratory manual. The experiments were carried out after the general principles involved had been thoroughly discussed in recitation periods. The exercises were used to describe the principles or illustrate their applications. No provision were made for student planning of experiments; there was little call upon the student to develop and use generalizing ability. Little or no opportunity was provided for the solution of real problems under laboratory conditions. The experiments and the manner in which they were taught were of the usual school pattern as reported by Anderson. (5)

Achievement examinations were administered as pretests at the beginning of the school term and provided a measure of initial status on the non-laboratory objectives. Intelligence quotients for each student were obtained through the use of the *Terman-McNemar Test of Mental Ability*. Final achievement was measured at the end of the nine-month school term. Retention scores were obtained for those students still in attendance at University High School the next fall, four months after completing the chemistry course.

Three laboratory examinations were used with the University High School classes. They included a performance test for evaluating the technical skills of students in handling apparatus, a test in which students criticized commonly found poor techniques, and a resourcefulness test.

All achievement examinations were constructed by the writer. Each item in the examination concerned with knowledge of facts and principles and application of principles was associated with some one of the forty-three basic chemical principles used to orient the course materials. These principles were adapted from the listing by Wise. (6) The tests were tried out on classes from a Minneapolis high school and two suburban schools. They were found to have reliability coefficients which were statistically significant and satisfactory for group analysis, the median being about .80. The questions, although having a wide range of difficulty, had an average difficulty of about 50 per cent. The greatest number of them had difficulties between 25 and 75 per cent.

The basic statistical techniques used in the analysis of the results were the analysis of variance and covariance. Adjustments on the criterion were made for whatever inequalities in mental ability and initial status existed among the classes by the technique of analysis of covariance. Significance levels were selected at the time

of the design of the investigation for determining the acceptance or rejection of the several null hypotheses under examination. The 5 per cent level was selected for rejection of null hypotheses concerning comparisons between University High School classes. The 1 per cent level was selected for null hypotheses concerning the average achievement of University High School and outside classes.

For the University High School experiment the null hypothesis concerning the average achievement of the objective concerned with the scientific method and attitude was rejected. Students taught in the inductive-deductive class showed significantly better achievement than those in the deductive-descriptive class. The other outcome for which a significant difference in average achievement was found in favor of the inductive-deductive class was the ability to identify proper laboratory techniques when they were encountered in actual working conditions. The observed differences (not statistically significant) were in favor of the inductive-deductive approach for the objectives of knowledge of facts and principles, application of principles in new situations, performance of laboratory techniques, laboratory resourcefulness, and general achievement.

The findings from the retention examinations covering applications of principles and scientific method and attitude showed differences in mean scores in favor of the inductive-deductive class of about the same magnitude as those from the achievement examinations or retests.

The analysis of data resulting from the addition of outside deductive-descriptive classes indicated a significant advantage in favor of the University High School inductive-deductive class over one of the outside classes for both the knowledge of facts and principles and application of principles objectives. The inductive-deductive class was superior to all outside classes for the scientific method and attitude objective.

The analysis of the results obtained was carried out in the following manner: An analysis of variance and covariance was carried out to test the hypothesis of homogeneity of the means of the scientific method and attitude examination scores of all the classes taking this examination. Differences were found to be significant and the hypothesis was rejected. The problem then became one of testing the significance of the differences between means of selected classes. The t-test of the significance of the differences between the means of achievement scores adjusted for differences in mental ability and pretest scores was applied. 'Vishart (7) showed that this was the appropriate test to use and worked out the procedures for carrying it out.

Because of the fact that the inductive-deductive class did as well or better than the deductive-descriptive class in the attainment of the general outcomes of a high school course in chemistry and was significantly superior with respect to the crucial problem of attaining knowledge of and ability in the use of the methods of science with an accompanying scientific attitude, the acceptance of the inductive-deductive method for use with future classes in chemistry at University High School was justified. This method of instruction is now in operation.

It was significantly demonstrated that this recommendati n would likely be valid for schools of the :ate. However, before such a recommendation could be completely validated, it would be necessary to carry through a cooperative experiment with a representative sampling of the schools of the state.

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A DETERMINATION OF MATERIALS DEALING WITH SOIL CONSERVATION AND SUITABLE FOR INTEGRATION INTO COURSES OF HIGH SCHOOL SCIENCE FOR GENERAL EDUCATION *

PART I. THE NEED FOR CONSERVATION EDUCATION AND THE ROLE OF THE SCHOOL IN PROVIDING IT

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ACCORDING to Renner,[1] "what challenges the nation must perforce challenge that nation's schools." He adds that "by this time, it should be clearly evident that conservation is not a mere fad or transitory movement, nor even the policy of any particular party. It is a national necessity and may not be overlooked nor treated lightly by our schools. It is assumed, therefore, that the present indifference of our schools must soon cease, and that they will assume before long the role of creating public opinion actively favorable for the consummation of conservational programs."

The evidence of waste such as, soil depletion, cut-over forests, polluted water resources and overgrazed grasslands leave no doubt as to the urgency of the need for conservation. The roll of the school in this highly controversial issue, however, is not so clearly defined. Among educational philosophers are:

(1) those who hold that the function of the school is to transmit the social heritage of the past,

(2) those who employ the sociological and scientific approach and insist that attention should be directed toward the needs of present-day institutions, and

(3) those who consider individual development and adaptation to a changing society as the chief function of the school.

Berkson [2] says:

> A marked change is indicated in reference to the social policy of the American school. The demand is that the school participate in effecting needed change in the social and economic life. In principle, the American school has always been devoted to social improvement, but hitherto the conception has been that diffusion of enlightenment and development of character would suffice to correct social evils; by improving the individuals who compose society, society itself would improve. Our schools have not generally drawn attention to changes needed in government, in laws, or in the structure of the social order. . . . The complaint of the critics is that the schools have become a bulwark of the established order of things. The school avoids the discussion of vital social problems; and if controversial issues are raised, a policy of neutrality is followed. But silence or "not taking sides" weights the teaching in the direction of maintaining things as they are.

* Paper presented at The National Association for Research in Science Teaching meeting at the Congress Hotel, Chicago, Illinois, February 1952. Based on dissertation for the degree of Doctor of Philosophy, University of Michigan, 1949.

[1] George T. Renner, *Conservation of Natural Resources*, New York: John Wiley and Sons, Inc., 1942, p. 26–27.

[2] I. B. Berkson, *Education Faces the Future*, New York: Harper and Brothers, 1943, p. 246.

In his concluding chapter Berkson[3] writes:

Our conception of planning may be regarded as a synthesis of the concept of interdependence and the idea of social control, united with the democratic regard for the common welfare. Since the laissez-faire idea is deeply rooted, to teach that it is passing away is not enough; a positive inculcation of the alternative idea, of a planned society, controlled from the point of view of general welfare, is essential. Moreover, since all types of society require planning, part of the educational task is to differentiate between the democratically planned society and other types. One of the best ways of doing this is to study in the concrete the various projects of national and regional planning that have developed in the United States in the past decade. A study of the idea of social control would include an examination of recent legislation relative to conservation of natural resources, assurance of social security, the reduction of unemployment, and the protection of wages and terms of labor service.

Certainly a subject should not be excluded from the curriculum simply because of its controversial nature; and, in the matter of opinions being voiced by teachers in the case of specific issues, Schorling and McClusky[4] offer the following suggestion:

Respect for pupil personality requires that a teacher will refrain from presenting a single solution to a pupil as a sort of fixed pattern that a pupil must accept. The democratic and American way of solving a social problem demands that the greatest number possible of our future citizens shall be taught to consider fairly the arguments for each of a number of alternative solutions. Hence there can be no question as to the teacher's right to deal with controversial issues, if the continued improvement of our fundamental institutions is to be assured. But to be able to "get away with this" the teacher must have a very broad scholarship, the ability to deal with delicate matters in an impersonal, objective, and fairminded way; the disposition to keep an argument free from emotion; and the habit of keeping his own views out of the picture until some pupil says, "Where do you stand?" then taking a definite position, but admitting that we all have our biases and prejudices and that at best his own opinion is merely one of alternative solutions.

At the very outset of the conservation movement Van Hise[5] foresaw the implications for education and said, "There is before us a profound and wide campaign of education which must start at the universities, in national and state organizations, and must extend from them through the secondary and primary schools to the whole people. . . . It is a campaign of education which will extend through generations."

In 1930, Gar A. Rousch[6] stated that "twenty years ago the standard remedy of the conservationist against all sorts of evils was legislation, but in the meantime the attitude has undergone a radical change and it is now seen that the chief need is for education."

It is noteworthy that about this same time The National Society for the Study of Education[7] in its Thirty-first Yearbook did not mention or call attention to the urgency of the conservation problem.

In 1938, however, the Committee on the Function of Science in General Education,[8] took the position that:

Social responsibility for the conservation of natural resources should be a recurring *theme* throughout the study of the use and control of energy and materials, and of man's dependence upon the environment for them . . . that for the sake of the broader good the socially sensitive person is willing to take measures counter to his own immediate comfort or that of the group with which he is identified, and it may be necessary to call upon many individuals to take such measures if natural resources are to be conserved for future generations. Some students may eventually vote on questions concerning the right of certain groups of which they themselves are members to control and exploit natural resources. The real problem of conservation is that of finding a principle on the basis of which decisions about the use of resources may be made with intelligent regard for all the interests involved.

Though it is important to show that it is only

[3] *Ibid.*, p. 321.

[4] Raleigh Schorling and Howard Y. McClusky, *Education and Social Trends,* New York: World Book Company, 1936, p. 140.

[5] C. R. Van Hise, *The Conservation of Natural Resources in the United States,* New York: Macmillan, 1910, p. 13.

[6] C. R. Van Hise and Loomis Havermeyer, *Conservation of Our Natural Resources,* New York: Macmillan, 1930, p. 105.

[7] *A Program for Teaching Science.* Thirty-first Yearbook of the National Society for the Study of Education, Part I, Chicago: Distributed by the University of Chicago Press, 1932, Chap. IV.

[8] Progressive Education Association, *Science in General Education.* New York: D. Appleton-Century Co., 1938, p. 288–90.

through use—or misuse—of the sciences that men use up fuel and soil more rapidly than they are replenished by natural processes, it is also essential to bring out the positive values of science as an aid in the conservation of natural resources.

The completeness of the report, with its suggestions for student activities and an extensive bibliography of books, pamphlets, and films, distinguish it as being the first attempt by a national committee to emphasize the importance of conservation as content in science courses. Therefore, it seems desirable to include here the "tentative list of generalizations" bearing on the major "generalization":* "Conservation of Exhaustible Natural Resources Is a Social Responsibility." They are as follows:[9]

1. Application of the sciences has enabled man to use up natural resources of fuel and soil more rapidly than they are replenished by natural processes.
2. The dispersion of material which results when metal objects are discarded or revert to rust renders quantities of metals unavailable to future generations.
3. Agriculture may be carried on by methods which conserve the fertility of the soil.
4. The development of synthetic processes using inexhaustible raw materials is an aid to conservation of natural resources.
5. Scientific forestry is being used increasingly to assure a permanent lumber supply and to prevent erosion and floods.
6. The building of dikes, levees, and artificial storage lakes along certain large rivers has been undertaken in many countries to provide flood control and protection against drought.
7. Increasing efficiency in the utilization of fuels and other materials tends to conserve natural resources.
8. In the future industry may have to secure most of its energy from sources other than coal and petroleum.
9. Can the discoveries of science be expected to provide new supplies of energy and materials to augment those now available from natural resources?

The committee points out that the list is not complete and that it is not to be offered as minimum essentials. Also, the list has "... no implication regarding the organization of learning activities—that is to be decided by the science teacher and his students."[10]

In 1940, Newlon[11] called attention to the importance of education in the conservation program by stating that "our schools have no greater responsibility than that of giving youth some understanding of these resources, of the way in which they have been and are being wasted, and of the problems connected with their conservation... and, above all, a vision of the good life which these resources make possible."

The Educational Policies Commission[12] made it clear that "realization of the basic importance of these resources, determination to use them for the common good through long-range planning, and general knowledge of appropraite remedial and preventive conservation procedures are among the marks of an educated citizen. Since future welfare and safety depend upon these things, the schools may well assume considerable responsibility for checking the ravages upon the heritage of the nation made by ignorance, indifference, carelessness, and unbridled selfishness."

In 1946, the committee of The National Society for the Study of Education[13] stated in the Forty-Sixth Yearbook that:

The importance of natural resources is recognized in the Atlantic Charter, which emphasizes the need for access to raw materials on equal terms for all states. In the United States we have recognized for a number of years the need

* The term "generalization," as used here by the committee of the Progressive Education Association, is not to be confused with the term "generalization" or "principle" as it is used in the scientific sense.

[9] Progressive Education Association, op. cit., p. 289–90.

[10] Progressive Education Association, *op. cit.*, p. 259.

[11] G. T. Renner and W. H. Hartley, *Conservation and Citizenship*, New York: Heath, 1940, Preface.

[12] Educational Policies Commission, *The Purpose of Education in American Democracy*, Washington: National Education Association, 1938, p. 112–13.

[13] *Science Education in American Schools*, Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, Chicago: Distributed by the University of Chicago Press, 1947, p. 36.

for conservation and replacement of forests, soil, and wildlife.

The wise use of the nation's natural resources is not only recognized as one of the important goals of education in a democracy, but it also has significant implications for other areas such as health, citizenship, worthy use of leisure time, and consumer education.

The committee further adds:[14]

The pupil may stop his learning with an awareness of the problem of conservation and with some comprehension of the factors involved and still fall short of achieving the ultimate purposes of science education. He may not, for example, orient his knowledge in the world scene. His ideas about conservation may be restricted to the situation studied or to the immediate locale. His knowledge must transcend such limits; it should influence his behavior in concrete ways. It should, for example, enter into his decisions in voting for political candidates or for bond issues. It should make him interested in the activities and actions of international bodies organized to further the wise utilization of natural resources. When scientific knowledge carries with it drives of these kinds, then science education is truly attaining its purpose.

Many excellent suggestions regarding student activities and utilization of source materials at all grade levels appear in the report. Perhaps the most significant statement by the committee, however, because of its implications for conservation education, is the concluding paragraph in the chapter on the objectives of science instruction. For added emphasis the statement appears in italics in the Forty-Sixth Yearbook:[15]

Science is today on a plane of high significance and importance. It is no longer, if indeed it ever was, a mysterious and occult hocus pocus to be known only to a select few. It touches, influences, and molds the lives of every living thing. Science teachers have a great opportunity and responsibility to make a large contribution to the welfare and advancement of humanity. The intellectual aspects of this responsibility are at least coequal in importance with the material. Science is a great social force as well as a method of investigation. The understanding and acceptance of these facts and this point of view and their implementation in practice will, more than anything else, make science teaching what it can and should be.

One of the earliest appraisals of the need for a program of conservation education was given by Winkenwerder[16] in 1909. He remarked that "much . . . as has been accomplished, the spread and the future of the movement depend upon a systematic education of the public. Such education must proceed along two distinct lines: education for a more scientific use of our resources, and education toward a better realization of the large significance of the conservation movement." The foregoing is especially notable when it is considered that three decades later curriculum makers were still wrestling with problems concerning special and general education. He points out that "The Forest Service when first organized as the Division of Forestry was little more than an education bureau."[17] Regarding a program for conservation education he suggests the following:[18]

In the public schools I should like to propose that we take up the studies in conservation only in connection with related subjects. In the classes in American History, in economics, and in general geography, for example, the importance of the conservation of natural resources and the relation of the conservation movement to the state and to other matters of social and political concern may be discussed. In the classes in physical and commercial geography and in manual training, in chemistry, botany, and agriculture the solution of problems concerned with a better scientific utilization of our resources should receive proper attention.

Winkenwerder's idea of integrating the study of conservation with other courses rather than establishing separate courses also shows an unusual foresight. The suggestion has been repeated many times by other individuals and groups. The committee on the Forty-Sixth Yearbook[19] took the same position when they stated that "the materials of these areas [consumer

[14] *Ibid.*, p. 38.
[15] *Ibid.*, p. 39.

[16] H. A. Winkenwerder, "Progress in Conservation," *Proceedings of the National Education Association*, (1909), p. 806.
[17] *Ibid.*
[18] *Ibid.*, p. 807.
[19] *Science Education in American Schools, op. cit.*, p. 46.

education, conservation, aeronautics, and health education] are of value chiefly for general education. . . . Their materials can be more effectively integrated with those of the regular courses of the science sequence and with other courses in the program of studies."

In 1937, "the first National Conference on Conservation Education held by a Federal Agency, or perhaps by any organization, was that called . . . by Commissioner of Education, John W. Studebaker."[20] The group emphasized that "the ultimate hope of conservation on a nation-wide scale is through education."[21] Particularly significant, though, is that "the conference recommended that the Office of Education enlarge its program at the earliest possible moment in order to serve the growing needs of the schools of the United States in the field of conservation education."[22]

In connection with soil conservation Preston[23] thinks "this problem is so acute and so vital to national welfare, that where necessary, interference with private rights is justified. However, actual government regulation should not come unless all possible efforts to achieve protection of the land through individual efforts assisted by government aid, research, demonstration, and education have proven a failure."

Eckelberry,[24] in commenting on the program proposed in the Miami Workshop for the schools of Ohio has this to say:

> Members of the workshop, in agreement with most students of the problem, emphasized the principle that conservation, instead of being taught as a separate subject, should be an emphasis running through many fields of subject matter—science, agriculture, home economics, social studies, and others. Many individual teachers in these various fields are doing effective teaching of conservation, but until conservation facts and principles permeate the entire curriculum from the kindergarden to the twelfth grade, the schools will not be rendering a service they should.

In stressing the importance of the subject he goes on to say that "a basic course in conservation education should be required of every prospective elementary-school teacher and every prospective secondary-school teacher of science, social studies, agriculture, and home economics, and should be made available to other teachers in training."[25] One of the most salutary outcomes was that "the workshop recommended the provision in the state Department of Education of a supervisor of conservation with an adequate staff and budget."[26]

About a year later there emerged a long-range program of research in conservation education in the state of Ohio. The plan included the following activities:[27]

> 1. determination of desirable outcomes and objectives to be done by pooling the judgments of a small group of conservationists and educators.
> 2. to study the status of conservation education in the United States.
> 3. to study the attitudes of superintendents, principals, supervisors, and teachers toward conservation education, and of the subject matter competence.
> 4. a survey of what teacher-education institutions are doing or planning to do with respect to the education of teachers in conservation.

Eckelberry[28] says "the plan for research which has been outlined seems to be a good one. But whatever its merits, there can be no doubt that this is one of the fields in which research is urgently needed; it should be carried forward without delay."

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[20] "First National Conference on Conservation Education," *School and Society,* XLVI (August 7, 1937), p. 172.

[21] *Ibid.,* p. 173.

[22] *Ibid.*

[23] R. J. Preston, "Soil Erosion; the Significance of the Problem and Its Attempted Control," *Journal of Geography,* XXXVII (November, 1939), p. 313.

[24] R. H. Eckelberry, "Conservation Education Looks Ahead," *Educational Research Bulletin,* XXIV (March, 1945), p. 58.

[25] *Ibid.,* p. 58–59.

[26] *Ibid.,* p. 59.

[27] R. H. Eckelberry, "Research in Conservation Education," *Educational Research Bulletin,* XXV (January, 1946), p. 20–21.

[28] *Ibid.*

In 1941, however, a survey had been made in Zanesville, Ohio in order to ascertain teachers' opinions on the teaching of conservation in the elementary school. In his findings, Carter [29] notes that "120 teachers [Grades I-VI] think that the most important phases of conservation for their pupils are:

(1) learning to conserve personal belongings, such as clothing, books, paper, pencils, toys, etc.;
(2) learning the real meaning of conservation, that is, use without waste;
(3) learning how conservation benefits each pupil;
(4) studying the interdependence of man and birds;
(5) learning to observe minutely; and
(6) studying the importance of topsoil."

The study is noteworthy chiefly for (1) being aware of the need for conservation, (2) broadening the definition of conservation to the extent that it might prove confusing rather than helpful, and (3) inclusion, along with material dealing with conservation, of extraneous material such as that dealing with scientific method (for example, no. 5 of the outline). In his conclusions Carter [30] remarks that "conservation education is a new learning ar , and it must evolve its own techniques and subject matter by a process of trial and error."

A study by Davis [31] provides data which seem to indicate that very little information on the causes of depletion and on the restoration and conservation of wildlife is entering our schools through textbooks and magazines. The results are given in Tables 1 and 2. While it is recognized that

[29] V. G. Carter, "Teachers' Opinions on the Teaching of Conservation in the Elementary School," *Elementary School Journal,* XLII (January, 1942), p. 367.

[30] Carter, *op. cit.,* p. 370.

[31] P. A. Davis, "Conservation Information in the Schools," *School and Society,* LIV (July 5, 1941).

TABLE 1

NUMBER OF PAGES DEVOTED TO CAUSES OF WILDLIFE DEPLETION AND WILDLIFE RESTORATION AND CONSERVATION IN 80 TEXT-BOOKS IN THE FIELD OF ELEMENTARY AND SECONDARY EDUCATION

Subject Field	Number of books	Average pages per book	Nature of the Material in the Books: Average pages per book on causes of wildlife depletion	Average pages per book on restoration and conservation of wildlife
Social Science	35	620	0.21	0.50
General Science	24	556	0.33	0.50
Biological	12	677	0.56	0.63
Agricultural	9	464	0.00	0.00

TABLE 2

NUMBER OF PAGES DEVOTED TO CAUSES OF WILDLIFE DEPLETION AND WILDLIFE RESTORATION AND CONSERVATION IN 27 EDUCATIONAL PERIODICALS

Areas covered by periodicals	Number of periodicals	Number of pages reviewed for 5-year period	Total pages on causes of wildlife depletion	Total pages on restoration and conservation of wildlife
Elementary Educ.	5	12,500	2.45	3.75
Secondary Educ.	16	34,161	5.10	9.52
Social Educ.	3	13,609	1.63	3.00
Science Educ.	3	6,763	35.00	82.25
Total	27	67,033	44.18	98.52

such a tabulation does not provide a true index of either the quantity or quality of instruction afforded in these areas, the results would seem to justify an expansion of both time and materials allotted to the field.

In an address to the National Council of Geography Teachers in 1936, George A. Duthie[32] declared that "every person should have a sane, common sense understanding of the principles of land use, which are essentially the underlying principles of conservation. Every person should understand how the use of the natural resources relates to his individual welfare." This point of view is held by many individuals and organizations, and illustrates the importance of the relation of conservation to general education.

Beard[33] stresses the same relationship but carries the concept a step further. He distinguishes between the type of education needed for two-thirds of our people who are without direct contact with our natural resources and the one-third who depend directly upon them. For the two-thirds he would "develop attitudes and understanding which will enable every good citizen to actively support or censure what public agencies are doing with natural resources."[34] For the one-third he suggests they be approached from the standpoint of personal interests. "Attitudes, of course, but of more importance specific training is needed to develop habits and skills in particular fields for this group."[35]

Stone[36] is substantially in agreement with the stand taken by Beard. He states that:

> Obviously most of the girls and many of the boys do not need the technical skills or the more extensive understandings required by conservation specialists; but if conservation is to be fully successful, it would seem that all youth do need "favoring" attitudes toward it. Hence it follows that the chief objective in this general teaching should be *improved attitudes,* which means, (1) the teaching of the information about natural resources and the skills in conservation that are essential for enlightened citizens in their support of conservation, (2) the provision of learning conditions conducive to the development of desired attitudes.

Stone submits the following guides to teachers in conservation:[37]

1. Keep the subject matter of conservation vitalized.
2. Have the school serve the community (near and far).
3. Discriminate between learning for appreciation and learning for execution.
4. Make pleasurable participation in learning a specific aim in teaching conservation.
5. Have the members of each class make specific beginnings at the junior-high school level to identify themselves with the conservation of a natural resource.
6. Guard against dulling interest by undue overlapping and mere repetition in succeeding years.
7. Definitized outcomes in terms of ability to recognize and interpret with intelligent enthusiasm non-technical processes.
8. Use pageantry to organize and stabilize attitudes.
9. Conclude high school study of conservation in terms of social justice.

Several examples might be cited to emphasize the fact that behavior is contingent upon factors other than knowledge. Mere knowledge of a particular referent * does not necessarily preclude favorable behavior with respect to it. Witness the incident related by Palmer[38] about the biology teacher who "... taught a lesson on fish by using undersized trout that he captured in a net out of season, in a posted area, and

[32] George A. Duthie, "Forestry and the Public Schools," *Journal of Geography,* XXXVI (May, 1937), p. 189.

[33] W. P. Beard, "Social Viewpoint in Conservation Education," *Social Education,* III (December, 1939), p. 637–640.

[34] *Ibid.,* p. 640.

[35] *Ibid.*

[36] C. W. Stone, "Principles of Teaching Conservation," *School and Society,* LII (December 21, 1940), p. 658.

[37] *Ibid.,* p. 659–60.

* A referent here is defined as anything—a person, a group of persons, an institution, an object, or an idea.

[38] E. Lawrence Palmer, "Conservation Education in the Schools; Report of School Activities and Suggestions as to Programs," *Nature Magazine,* XXXII (November, 1939), p. 512.

that he held captive without a license to do so." There is considerable evidence to indicate that one of the most potent factors in determining behavior is attitude. According to Young [39] "all we can say is that when the time comes to act, the attitude will enter in as an essential factor." If attitudes are the determinants of behavior, as Hoover [40] has pointed out, then Ward and Stone, among others, are justified in their contention that the formation of favorable attitudes toward conservation is one of the main problems of education. That attitudes can be taught is implicit in the objectives set forth by some of the official committees on science teaching.[41] If they cannot be taught then the listing of them as important objectives would appear to be rather dubious procedure. There is ample evidence, however, that they can be taught. Thorndike [42] has summed up the research in these words:

> We now know that the fundamental forces which can change desires and emotions, directing them into desirable channels, are the same as change ideas and actions. A human being learns to react to the situations of life by such and such wants, interests, and attitudes, as he learns to react to them by such and such percepts, ideas, and movements.

There was a time, as was pointed out earlier, when it was thought that legislation would solve most of the conservational problems. For example, in his study, Quaintance [43] writes that "state laws requiring conservation education were found in Wisconsin, Florida, and Oklahoma, and laws in special fields of conservation, particularly in forestry, in Georgia, Tennessee, and Mississippi." With respect to the desirability of such legislation the investigator adds that "judgment based on conditions in these states would indicate that, in general, similar laws might be discouraged until teacher training in conservation becomes operative."[44] John Caldwell [45] of the Educational Service Department of Conservation, Nashville, Tennessee, very bluntly told the Conference on Education in Conservation which was held in Detroit, Michigan, February 16, 1939, that "if any of you are thinking of passing legislation to secure conservation teaching, let me warn you, because we have had it for nineteen years and it has done a lot of harm."

With regard to the most efficacious means of achieving a wholesome program of conservation Renner [46] stated, in 1938, that ". . . despite the considerable amount of recent desirable legislation which has been accomplished under the present administration, it may be reiterated that education is still the most needed factor in promoting conservation." It is worth noting that at a later date the same author had this to say: [47]

> It may be stated at this point, however, that a conservation which rests solely upon education and persuasion must fail at almost every point where it comes into conflict with individual inter-

[39] Kimball Young and others, *Social Attitudes,* New York: Henry Holt and Company, 1931, p. 8–9.

[40] Floyd W. Hoover, "Attitudes, Those Elusive-Behavior Determinants," *Educational Administration and Supervision,* XXXI (April, 1945), p. 215–22.

[41] Annual Report of the Conservation Committee of the Central Association of Science and Mathematics Teachers, *School Science and Mathematics,* XL (January, 1940), p. 74; *Science Education in American Schools,* Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, Chap. III, Chicago: Distributed by the University of Chicago Press, 1947.

[42] Edward L. Thorndike, *The Psychology of Wants, Interests, and Attitudes,* New York: D. Appleton-Century Company, 1935, p. 217.

[43] Charles W. Quaintance, "Conservation Education in the Schools and Colleges of the United States," *Cornell University Abstracts of Theses,* 1939, Ithaca, New York: Cornell University Press, 1940, p. 83.

[44] *Ibid.*

[45] National Wildlife Federation, *Conference on Education in Conservation,* Washington: The Federation, 1939, p. 30.

[46] G. T. Renner, "Conservation as a Unit of Study in Geography," *Education,* LVIII (January, 1938), p. 284.

[47] G. T. Renner, *Conservation of Natural Resources,* New York: John Wiley and Sons, Inc., 1942, p. 25–26.

ests and property rights. In the end we must build our educational program so that it will eventually be expressed in terms of public administration and legality.

Here is perhaps the biggest challenge which has yet appeared on the horizon. Moreover, it insists upon staying on the horizon and growing larger year by year. Can people, organized democratically, conserve the physical foundation of their social order? No one seems to know, but to deal with such problems we have insisted upon building and maintaining a free and universal system of public education. This freedom for education is not just for fun, but for the serious purpose of creating public intelligence in social and economic affairs. Will we put education to work building a popular will for the conservation of natural resources before it is too late?

PART II. THE SELECTION AND EVALUATION OF MATERIALS OF SOIL CONSERVATION AND THE ASSIGNMENT OF VARIOUS ASPECTS OF THEM TO SCIENTIFIC PRINCIPLES AND/OR TO SCIENTIFIC ATTITUDES

The purpose of this investigation was to select and organize, from periodical literature, materials of soil conservation suitable for integration into courses of high school science for general education.

The first step consisted of developing a tentative outline of the various phases or aspects of soil conservation, which could be made to serve as criteria in locating and identifying such materials in representative newspapers and magazines. The outline was formulated by combining:

a. lists of such aspects obtained by the investigator from courses and seminars in conservation;
b. such additional aspects as were found in periodical literature and in books dealing with soil conservation;
c. such aspects and refinements of statements as were stated or suggested during interviews and discussions with authorities on conservation.

From all the materials thus obtained, the following tentative outline was developed:

CRITERIA FOR THE SELECTION OF ITEMS IN PERIODICAL LITERATURE WHICH DEAL WITH ASPECTS OF SOIL CONSERVATION

An item was considered to be an appropriate aspect of soil conservation if it provided information or instruction regarding the nature and effects of the

A. Removal of the soil itself, and the depletion of its organic, inorganic, and water content, through

I. Natural agencies or processes, such as

1. Running water
2. Wind
3. Drought
4. Heavy rain and/or hailstorms
5. Thawing of snow
6. Break-up and melting of ice
7. Heaving or "spewing" of top soil by alternate freezing and thawing
8. Freezing and thawing of capillary water
9. Leaching
10. Backing up of sea water through porous strata
11. Wave action on ocean and lake shores
12. Volcanic action

II. Man's practices which accelerate natural removal and depletion, such as

1. Up-and-down hill plowing
2. Plowing on rolling lands
3. Seedbed preparation on steep hillsides
4. Burning of stubble or vegetative cover
5. Removal of vegetative cover
6. Breaking of sod land on steep hillsides
7. Growing of clean-tilled crops
8. Excessive mono-culture
9. Continuous cropping without fertilization
10. Deforestation and subsequent neglect of such areas
11. Harvesting by fleet methods followed by neglected cultivation
12. Irrigation resulting in the deposition of silt
13. Unskillful use of water for irrigation resulting in alkali concentration
14. Overgrazing
15. Use of pulverizing machinery, such as rotary plows, etc.
16. Excessive drainage
17. Plowing, fallowing, etc., in areas where strong winds are prevalent
18. Excessive pumping of underground water supplies for irrigation and industrial uses
19. Strip-mining
20. Methods of storing manure which result in loss of nutrient value
21. Continuous chemical fertilization without manuring

B. The building and improvement of soil through the biotic action of

I. Plants, such as

1. Bacteria of decay
2. Fungi
3. Lichens

II. Animals, such as

1. Protozoans
2. Roundworms or nematodes
3. Earthworms
4. Insect larvae
5. Gophers, ground squirrels, woodchucks, and other mammals

C. Conserving of the soil itself and of the maintenance or increase of its organic, inorganic, and water content, through

I. Agricultural practices, such as

1. Reclamation of gullies
2. Construction of farm ponds
3. Application of commercial fertilizers
4. Spreading of lime
5. Application of manures
6. Protection of manure from weathering during storage
7. Composting of organic wastes
8. Contour cultivation
9. Stripcropping on the contour
10. Building of contour furrows
11. Planting of orchards and vineyards on the contour
12. Contour fencing
13. Building terraces, terrace outlets, diversion channels, and sod waterways
14. Construction of open farm drainage ditches
15. Seeding or re-seeding to establish permanent pasture
16. Seeding or re-seeding of steep slopes and unproductive land
17. Use of stubble, cover-crops, and protective mulches to hold the soil.
18. Trashy cultivation
19. Use of sub-surface and chisel plows
20. Keeping soil cloddy to resist wind erosion
21. Disking one way
22. Furrowing to reduce blowing
23. Fallowing to increase absorptive capacity of soil in semi-arid areas
24. Plowing under green manures and crop residues
25. Irrigation of crops
26. Employment of systematic crop rotations
27. Draining of land
28. Tearing out old fence ridges
29. Reducing the number of animals on a range
30. Adaptation of animal types best suited to any particular range
31. Transferring animals from one range to another
32. Rotation grazing
33. Establishment of windbreaks and shelterbelts
34. Circulation of livestock by means of proper location of farm buildings, water supply, etc.
35. Using devices for controlling the drifting of snow

II. Forestry practices, such as

1. Reforestation
2. Thinning, pruning, and utilizing small dimension products
3. Selective cutting designed to sustain yield
4. Fire control
5. Insect control
6. Disease control
7. Prevention of grazing damage

III. Flood control, irrigation, and reclamation projects, such as

1. Construction and location of dams to create storage reservoirs, retarding basins, and desilting basins
2. Construction and/or reinforcement of levees and dykes
3. Construction of floodways
4. Channel improvements
5. Headwater control through re-vegetation, terracing, and minor engineering works
6. Landscaping cuts and fills along roads and highways
7. Treatment of strip-mined areas by tree planting, leveling, and developing pasture areas

IV. Surveys, studies, or appraisals.

1. To determine water content in watersheds
2. To forecast spring and summer run-off
3. To determine degree of pollution of surface streams
4. To determine ways and means of inducing artificial precipitation
5. To determine location and accessibility of water supplies

V. Educational, legislative, and administrative practices, such as

1. Formation of soil and water study groups
2. Soil contests, demonstrations, and experiments
3. Training and/or appointment of foresters, agronomists, land planners, agricultural agents, and other technical workers
4. Using bank credit clubs, i.e., requiring soil conservation practices as a basis of crop loans
5. Using services of soil conservation districts, county agricultural agents, agricultural extension service, college and university experiment stations, Forest Service, etc.
6. Land classification and retirement of marginal lands from cultivation
7. Rationing of water
8. Grants-in-aid for carrying out farm programs

9. Sale or proposed sale of public lands
10. Granting of grazing permits or privileges
11. Establishment of public areas as national and state forests, refuges, parks, etc.
12. Grants or refusals of appropriations for the construction of dams, reservoirs, floodways, etc.
13. Refusal of government aid for off-farm practices, such as buying manure from stockyards
14. Granting of land for forestry practices
15. Activities of Future Farmers of America and 4H groups

The validity of the outline was established by submitting it to three authorities, all of whom were professors in the School of Forestry and Conservation at the University of Michigan. In regard to the use of group judgments in the determination of validity Keeslar,[48] summarizing the available research on the problem, has this to say:

> ". . . group judgments are both reliable and valid within the frame of reference set up for them providing (1) that the judges be well-trained and experienced, i.e., experts in their fields of specialization, and (2) that the criteria in terms of which the judgments are to be made be clearly and concisely stated for that purpose.

The three authorities were instructed to make any deletions, amendments, or suggestions for its improvement.

The adequacy of the outline was tested by experimental application in analyzing the articles of three newspapers and two magazines, for the purpose of ascertaining the materials of soil conservation which they contained. Four issues of *The Des Moines Register, The Daily Oklahoman,* and *The Spokesman-Review* were selected at random from the issues of each of the newspapers published during March, 1948. The November, 1947 issue of *The Reader's Digest* and Volume III, No. 2, 1943–44 of *The Land* were used in the sampling. The only materials not used in this preliminary examination were advertisements, letters of opinion written to the editors, and the ones indicated in the table of contents as being fiction. A total of 42 articles were thus examined.

[48] Oreon O. Keeslar, *Contributions of Instructional Films to the Teaching of High School Science,* Unpublished doctor's dissertation, University of Michigan, 1945, p. 104–15.

It was found that the outline, as constructed by the investigator and validated by the three experts in conservation, was entirely adequate for the identification and selection of materials of soil conservation.

SELECTION OF PERIODICALS FOR ANALYSIS

The periodicals used in this investigation consisted of a month's issues of four newspapers and a year's issues of three magazines. The newspapers selected were *The Des Moines Register, The Daily Oklahoman, The Spokesman-Review,* and *The New York Times.* The magazines selected were *The Reader's Digest, The Country Gentleman,* and *The Land.*

With the newspapers it was thought that a selection based upon geographical location would be most representative, not only of physiographic and climatic conditions, but also, of methods of farming peculiar to each area. For example, *The Des Moines Register* was selected as being representative of the corn belt; *The Daily Oklahoman,* of the dust bowl; *The Spokesman-Review* of farming as it is carried on in the northwest; and *The New York Times* of the eastern section of the United States.

For the magazines to be analyzed in the study, *The Reader's Digest* was selected on the basis of its wide circulation and also because it was found to be first on the list of five magazines read by the one hundred ablest readers in Buswell's [49] study.

The Country Gentleman was selected on the basis that it was representative of magazines having a wide circulation in rural areas.

The Land was included because it was representative of those organizations which are primarily interested in furthering soil conservation and better land utilization.

The issues of the four newspapers employed in the analysis were those for the month of March, 1948. The magazines used in the investigation composed all the issues of each for the year 1947.

[49] Guy T. Buswell, *How Adults Read,* Supplementary Educational Monographs No. 45, Chicago: University of Chicago Press, 1937, p. 41.

TECHNIQUES OF THE ANALYSIS

All the materials in the selected issues were examined with the exception of (1) advertisements, (2) letters of opinion to the editors, and (3) those which the table of contents indicated to be fiction. Any statement, passage, etc., which dealt with one or more points of the outline was designated as a "knowledge" of conservation education. Every knowledge was recorded on a tabulation sheet. The following table shows the distributions of articles and

TABLE 1

THE NUMBER OF KNOWLEDGES OF CONSERVATION EDUCATION FOUND IN THE ARTICLES OF THE PERIODICALS ANALYZED

Publication	Number of Articles Containing Knowledges of Conservation Education	Number of Knowledges of Conservation Education
Des Moines Register	52	324
The Daily Oklahoman	49	315
Spokesman-Review	46	292
New York Times	50	279
Reader's Digest	37	161
Country Gentleman	123	574
The Land	86	527
Total	443	2472

knowledges of conservation education found in them.

The 443 articles of conservation education varied widely in scope. For example, one article dealt solely with reducing the number of livestock on a given area in order to prevent overgrazing; while another article was concerned with some of the major effects of overgrazing as a result of exploitation of the ranges by private stock outfits. Besides the variation in the scope of the articles, there was extensive duplication among them. It was decided, therefore, to combine all the knowledges into major aspects or phases that would be mutually exclusive. Revisions in wording were made as often as was necessary as the work proceeded in order that an aspect would unquestionably include all the knowledges which logically seemed related.

All the 2,472 knowledges of soil conservation were combined into 49 aspects. For convenience, the aspects or phases thus determined were then grouped under five major headings as follows:

A. Aspects related to natural agencies or forces
B. Aspects related to agricultural, ranching, and forestry practices
C. Technological aspects
D. Educational aspects
E. Legislative and administrative aspects

Table 2 indicates the number of aspects classified under the five major headings:

TABLE 2

THE NUMBER OF ASPECTS OF KNOWLEDGES ASSIGNED TO EACH MAJOR HEADING OF SOIL CONSERVATION

A. Aspects related to natural agencies or forces	12
B. Aspects related to agricultural, ranching, and forestry practices	17
C. Technological aspects	6
D. Educational aspects	5
E. Legislative, and administrative aspects	9
Total	49

EVALUATION OF THE ASPECTS

Four specialists in the teaching of science, all of whom offer courses in that field at the university graduate level, agreed to evaluate the aspects of soil conservation. Justification for the use of such judgments has been cited previously from evidence summarized by Keeslar.[50] Further evidence[51, 52, 53, 54, 55] is presented by Keeslar

[50] Keeslar, *loc. cit.*

[51] Fred P. Frutchey, "Measuring the Ability to Apply Chemical Principles," *Educational Research Bulletin* (Ohio State University), XII (December 13, 1933), p. 255–60.

[52] Willard C. Olson, and Muriel M. Wilkinson, "The Measurement of Child Behavior in Terms of Its Social Stimulus Value," *Journal of Experimental Education*, I (1932), p. 92–5.

[53] Harold H. Anderson, "Domination and Integration in the Social Behavior of Young Children in an Experimental Play Situation," *Genetic Psychology Monographs*, XIX (August, 1937), p. 343–408.

[54] Margaret Nesbitt, *Adult Child Relationships, Student Child Relationships in the Nursery School*, Unpublished doctor's dissertation, University of Michigan, 1942, p. xii+204.

[55] Ralph W. Tyler, "Ability to Use the Scientific Method," *Educational Research Bulletin*, (Ohio State University), XI (January 6, 1932), p. 1–9.

which indicates that the average of the ratings made by four raters is almost identical with the average of those made by several raters, provided that the criteria, in terms of which the ratings are to be made, are clearly and concisely stated.

A copy of the list of 49 aspects was submitted to each specialist with the following explanations and instructions:

The attached list is comprised of aspects of soil conservation.

These aspects of soil conservation were extracted from newspapers and magazines, according to an outline whose validity has been determined.

The next step is to determine whether or not and to what extent these aspects have value for inclusion in courses of high school science for general education. Your assistance is respectfully requested in performing this task.

Please give each aspect *one* of the following values:

a. Is essential for inclusion in one or more high school courses of science .... (value +2)
b. Has some positive value for inclusion in such courses.............. (value +1)
c. Is neither well-suited nor poorly-suited for inclusion in courses of high school science............... (value 0)
d. Is poorly-suited rather than well-suited for inclusion in such courses (value —1)
e. Is totally unsuited for inclusion in any high school science course.... (value —2)

Examine each aspect and indicate your judgment with respect to its value for inclusion in courses of high school science by circling the appropriate number on the scale to the right.

Very truly yours,
E. EUGENE IRISH

Blanchet's[56] scale was considered to be satisfactory for evaluating the aspects, when reworded for purposes of this study.

The values assigned to each aspect by the five evaluators (including the investigator) were tabulated, and the algebraic sum of these evaluations was computed. For example, the aspect, "Transferring or shifting livestock to restore fertility and to prevent overgrazing," was assigned a value of +2 by two evaluators, a value of +1 by one evaluator; a value of —1 by one evaluator; and a value of 0 by one evaluator. The algebraic sum of these values is $(2 \times +2) + (1 \times +1) + (1 \times -1) + 0 = 4$.

The algebraic sum of the evaluations of each aspect was assumed to be the value of that aspect. On the basis of these results, the 49 aspects were arranged in decending order according to their values, within the major groupings or headings in which they had previously been placed.

A summary of the tabulation of all evaluations of the 49 aspects of soil conservation is as follows:

1. Five of the 49 aspects were unanimously evaluated as essential for inclusion in courses of high school science by the five evaluators.
2. Thirty-three of the 49 aspects received a total positive value ranging from +1 to +10 from the judgments of the five evaluators.
3. Fourteen of the 49 aspects received a total negative value ranging from —1 to —10 from the judgments of the five evaluators.
4. Only one of the 49 aspects was unanimously evaluated totally unsuited for inclusion in courses of high school science by the five evaluators.

ASSIGNMENT OF ASPECTS TO SCIENTIFIC PRINCIPLES AND/OR SCIENTIFIC ATTITUDES

The principles of science selected for use were the 270 in the "composite list of principles of physical science" assembled by Wise,[57] and the 300 in the "master list of major principles from the biological sciences" assembled by Martin,[58] The scientific attitudes selected for use were the five major ones formulated by Curtis.[59]

[56] Waldo E. Blanchet, *A Basis for the Selection of Course Content for Survey Courses in the Natural Sciences,* Unpublished doctor's dissertation, University of Michigan, 1946, p. 39.

[57] Harold E. Wise, *A Determination of the Relative Importance of Principles of Physical Science for General Education.* Unpublished doctor's dissertation, University of Michigan, 1941. pp. 248–91.

[58] W. Edgar Martin, *A Determination of Principles of Biological Sciences of Importance for General Education.* Unpublished doctor's dissertation, University of Michigan, 1944, p. 111–57.

[59] Francis D. Curtis, *Some Values Derived*

Every principle and every attitude was typed on a separate index card, 4" × 6" in size. Every aspect which received a positive value was typed on a separate card, 3" × 5" in size.

Every aspect was considered in relation to every principle and every attitude, in order to determine whether the material it included could readily be made to contribute to the understanding of that principle, or to assist in the development of that attitude. In every case wherein such a contribution was evident, the smaller card on which the aspect had been typed, was clipped to the corresponding index card on which the principle or attitude appeared.

Some of the aspects could appropriately have been assigned to more than one principle and/or attitude. It was arbitrarily decided, however, to assign every aspect to only that principle or that attitude to which its contribution was deemed to be most apparent.

The defensibility of these assignments was checked by having two of the judges, who had evaluated the aspects, examine independently the principles and attitudes and the various aspects which had been assigned to them. After completing their examinations, both judges agreed that every assignment of an aspect to a principle and an attitude was defensible.

Lists 1, 2, and 3 present the results of these allocations.

List 1

The Principles of Physical Science with the Aspects of Soil Conservation Assigned to Them

* 1. When elevations or depressions are created upon the surface of the earth, the elevations are usually attacked by the agents of erosion, and the materials are usually carried to the depressions.

Loss of top soil due to run-off which may be caused by excessive rainfall, melting of snow and ice, breaks in dams, reservoirs, levees, etc.

Loss of top soil due to wind.

Heaving or "spewing" as a result of freezing and thawing which causes loose soil to be thrown up on the surface, thus exposing it to wind and running water.

Deposition of debris and other materials on productive land by running water.

Deposition of debris and other materials on productive land by wind.

2. The natural movements of air, water, and solids on the earth are due chiefly to gravity plus rotation of the earth.

Restoration of soil water by rains and melting snow.

3. Condensation will occur when a vapor is at its saturation point if centers of condensation are available and if heat is withdrawn.

Inducing and preventing precipitation by dry-ice methods.

List 2

The Principles of Biological Science with the Aspects of Soil Conservation Assigned to Them

* 1. When the balance of nature is disturbed, disastrous results often follow.

Removal of forage and vegetative cover by overgrazing or burning.

Deforestation and subsequent neglect of the land.

Tilling and cultivating the soil by methods which accelerate the action of wind and running water.

Cultivating the soil by methods which result in the loss of plant nutrients.

2. All plant and animal life, along with the climate and varying weather, play an active part in helping to form and to change the soil.

Decay of dead plants and animals by bacterial action.

Aeration of soil by earthworms.

Release of plant food by acids given off from decay of organic matter and from biological activity within the soil.

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from Extensive Reading in General Science. Teachers College Contributions to Education, No. 163. New York: Teachers College, Columbia University, 1924. p. 41–9.

* List 1 reads thus: The aspect, "Loss of top soil . . ." was judged to contribute to the understanding of the principle, "When elevations or depressions are created. . . ."

* List 2 reads thus: The aspect, "Removal of forage and vegetative cover . . ." was judged to contribute to the understanding of the principle, "When the balance of nature is disturbed. . . ."

3. Water is essential to all living things because protoplasmic activity is dependent upon an adequate water supply.

Building or constructing devices that tend to hold water where it falls or that prevent its running off too rapidly.
Irrigation and/or draining of land by constructing and maintaining small ditches, canals, troughs, etc.
Impounding and/or diverting water by constructing and maintaining dams, reservoirs, stockponds, etc.

4. A balance in nature is maintained through interrelations of plants and animals with each other and with their physical environment.

Transferring or shifting livestock to restore fertility and to prevent overgrazing.
Cultivating crops which maintain and/or increase the amount of plant nutrients in the soil.
Controlling soil loss by maintaining and/or restoring vegetative cover.
Immediate or prompt reforestation after the cutting of trees.
Tilling and cultivating by methods which reduce the action of wind and running water.

5. Plants and animals are directly or indirectly dependent on the soil.

Recovering, composting, and storing of manures to prevent loss of plant nutrients.
Restoring plant nutrients by green manuring and/or the application of animal manures and commercial fertilizers.

6. Only the top soil, with its rich organic matter, its porous structure, and its living organisms, can hold the water and provide the minerals necessary to the life of most plants.

Recovering, composting, and storing of manures by methods which result in the loss of plant nutrients.
Removal of plant nutrients due to the impact of heavy rains and run-off.

List 3

The Scientific Attitudes with the Aspects of Soil Conservation Assigned to Them

* 1. Habit of weighing evidence with respect to its pertinence, soundness, and adequacy.

Classifying land for purpose of determining uses for which it is best suited.
Promoting practices of soil conservation by contests, demonstrations, and exhibits.
Promoting agreements by farmers to carry out certain conservation practices, such as construction and use of drainage ditches, tile drainage, liming materials and fertilizers.
Establishing of soil conservation districts.
Authorizing and appropriating funds for flood-control projects by Congress.
Retiring of sub-marginal land by the government for grazing purposes.

2. Respect for another's point of view, an open-mindedness, and willingness to be convinced by evidence.

Using services of soil conservation districts, county agricultural agents, agricultural extension services, college and university experimental stations, Forest Service, etc., in establishing better practices of soil conservation.

The findngs from Lists 1, 2, and 3 may be summarized as follows:

1. All thirty-three of the aspects of soil conservation which had received a positive value were assigned to principles and/or attitudes.
2. Seven were assigned to three principles of physical science.
3. Nineteen were assigned to six principles of biological science.
4. Seven were assigned to two scientific attitudes.

CONCLUSIONS

Insofar as the results of this investigation may be valid, the following conclusions seem justified:

1. The outline developed in this investigation, and which served as a basis for selecting, from periodical literature, materials dealing with soil conservation, appears to possess a validity sufficiently high to justify its use in investigations of periodical materials dealing with conservation.

2. Periodical literature, of the nature used in this investigation, contains much material dealing with soil conservation.

3. Many of the materials dealing with soil conservation, as presented in the periodical literature, have positive values for

* List 3 reads thus: The aspect, "Promoting practices . . ." was judged to assist in the development of the attitude, "Habit of weighing evidence. . . ."

integration into courses of high school science for general education.

4. Each of the aspects or phases of soil conservation, which received a positive value for integration into courses of high school science, contains materials which may be employed in one or both of the following ways:

a. To contribute to the understanding of principles of physical and biological science.

b. To assist in the development of scientific attitudes.

5. The aspects are valuable as sources of materials for courses in conservation at the secondary level.

6. The list of aspects apparently is not complete, and needs to be supplemented by others which may be determined from further studies.

THE PRESENT STATUS AND FUTURE TRENDS IN THE FIELD OF ATOMIC ENERGY IN THE EDUCATION OF SCIENCE TEACHERS *

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THE atomic age dawned at 5:30 a.m., July 16, 1945 in the New Mexico desert. On August 5, 1945 a B-29 named the *Enola Gay* dropped the first atomic bomb on the city of Hiroshima and improved the art of war by twenty million per cent. From the time that the Manhattan Project demonstrated to us that a small piece of plutonium can be converted to the equivalent of about 250 million pounds of TNT, there has been an urgent need to disseminate information concerning the facts and implications of atomic energy as it pertains to the United States and to the world.

Books, magazine articles, motion pictures, radio and television programs have all been utilized in an effort to inform the American people of the potentialities and evils of atomic energy. Teachers all over the nation have discovered, much to their discomfiture, that atomic energy is playing an increasingly important role in their classrooms. Such terms as fission, fusion, isotope, and radio-activity have graduated from science fiction to the daily paper. With this wholesale broadcast of information, and concomitant social and technical problems, teachers are faced with an additional responsibility; that of dealing intelligently with the facts and issues concerning atomic energy in their classes. What then, is the present status of atomic energy education in institutions which prepare teachers for work in the schools of the atomic age?

In an effort to determine what steps are being taken by teacher training institutions to meet the challenge presented by the advent of the atomic age, two questionnaires were circulated to over fifty colleges and universities throughout the United States. Selected members of the National Association for Research in Science Teaching were asked, in one questionnaire, for specific information concerning their institution's program with reference to the following:

1. The program for the preparation of teachers in general in the field of atomic energy.
2. The program for the preparation of science teachers in the field of atomic energy.
3. The place of this program in the total teacher-education curriculum; *i.e.*, is it a function of science courses or professional education courses?

The data gathered indicates that some effort is being made to make prospective teachers familiar with the facts and implications of atomic energy. Only five per

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cent of the institutions indicated that they had no program whatsoever in the field of atomic energy education. In the remaining ninety-five per cent of the reporting institutions, the program seems to range from an incidental exposure to atomic energy through required science courses on the general education level, to an intensive study of the social, technical, economic and political implications of atomic energy, and how these facts may be taught in the classroom.

Programs designed for the preparation of all teachers introduce the concepts and generalizations of atomic energy through courses in the physical and biological sciences. The pattern seems to be fairly constant. Either the student is required to take courses in both the physical or biological sciences, or he may elect to take either one or the other of these sciences. While these courses are not designed to provide atomic energy education to the exclusion of all other topics, it is indicated that one unit, or at least some given block of time, is devoted to the study and discussion of atomic energy.

About forty per cent of the replies received indicated that students were free to elect the science courses they wished to take in order to fulfill their general education requirements. The remaining sixty per cent pointed out that all students were required to take some science course which dealt, at least in part, with the development and use of atomic energy.

It would seem, therefore, that the concepts concerning atomic energy that teachers in general receive as a part of their preservice training depend upon two factors: 1) the science courses that the student elects in the general education program, and 2) the emphasis placed on atomic energy by the instructor in any given course.

The programs reported for the training of future science teachers depend largely upon the science courses to impart the basic concepts of atomic energy to the prospective teacher. Some institutions indicated that their programs included guest lecturers, trips to cyclotrons, audio-visual aids, and other devices to enrich the program, while others reported that atomic energy was treated only "incidentally" and "in a very elementary fashion."

The impression is gained that the prospective science teacher receives considerably more instruction in the theory and application of atomic energy than does the teacher who will work in other areas, for in every instance reported, it was indicated that when specific training in atomic energy was given, it was the function of the science courses to impart this knowledge, although other areas were cited as making additional contributions. Several institutions indicated that they were offering graduate science courses which dealt exclusively with atomic energy, but no institution reported an undergraduate course which dealt primarily with atomic energy.

The data gathered indicates that only thirty per cent of the institutions include atomic energy education in professional education courses. In all cases reported, it was the policy of these institutions to "integrate" atomic energy education in special methods courses in the teaching of science, or general methods courses provided for all teachers. As in other areas of the teacher training programs, there was no report of a course in the professional education area which dealt exclusively with atomic energy education.

The Atomic Energy Commission has made available a summary of special teacher training programs in the field of atomic energy education. A second questionnaire was sent to the institutions which reported programs for the years 1947–1950. This second questionnaire requested information with reference to the following:

1. The present status of the program reported to the Atomic Energy Commission for the years 1947–1950.
2. Any specific modifications of the program reported to the Atomic Energy Commission.
3. Any future changes that were being considered by the teacher training institution in the area of atomic energy education.

The replies received indicated that forty per cent of the colleges and universities have

substantially the same type of program as they did in the years 1947–1950. An analysis of these programs shows that they were either workshops or institutes for teachers and administrators in the field, and were held, but for two exceptions, during the summer months. The scientific, economic and social implications of atomic energy were discussed in these meetings.

The sixty per cent of the institutions indicating changes in their programs of atomic energy education stated that the workshops and institutes have been abandoned for two major reasons: 1) the enrollment in such undertakings was so small that it became impossible, economically, to continue such programs, and 2) more emphasis is now being placed upon "integrating" atomic energy education into existing courses with the consequence that fewer special institutes and workshops are being offered.

There seems to be, at the present time, no clear-cut program emerging for the training of prospective teachers in the area of atomic energy. Unsolicited comments received in answer to the questionnaires reveal that there is no complete agreement as to what the "ideal" program for training future teachers in this area might be. One comment, which is representative of similar responses, is that "there is some dissatisfaction with the understandings which . . . the younger students who have not taught before may be receiving in this matter."

Several replies indicated that a separate field of atomic energy education would be an undesirable solution to the problem. The opinion was offered that to provide such training "would be a mistake. Education is an integrated enterprise, and any college faculty which is alert to what is going on around it will attempt to take account of present and future changes and implications of the development and use of atomic energy for military and peaceful uses."

The actual direction this "integrated" program might take is likewise an issue upon which there seems to be no majority opinion. One suggestion was "that information concerning atoms is most decidedly a part of science courses. In the same way, other concepts concerning atomic energy would be a part of courses in the fields of the social studies, and so on."

However, the feeling was expressed that in the areas other than science the teacher-training institutions "are not equipped either as to facilities or as to personnel to handle atomic energy on a technical level." The observation was also made that science teachers feel "practically no obligation for the social problems, although they often talked glibly about the humane or ethical aspect of atomic energy," and that while science teachers often teach the technical aspects of atomic energy, they feel this aspect "is more important than any of the social problems which they also frequently said are not 'our' responsibility."

There can be little doubt that Mr. David E. Lilienthal's statement "no undertaking is more critically important nor more urgently needed than the education of American youth in the basic facts and essential meanings of atomic energy," represents an assumption which can be endorsed by all who are interested in the training of prospective teachers. Translating this goal into a functional program seems to present unusual difficulties when it is recognized that even our most learned scientists deny firm concepts of the total meaning and implications of atomic energy. Therefore it has been suggested that "research in atomic energy, just as engineering advances in aviation, is primarily for the highly trained specialists, and the teacher in the grades or in the high school cannot profitably discuss this material before his classes."

Another point of view concerning this issue was expressed in the statement that "one recognizes immediately that it is not necessary to understand fully the complex nature of fire or of the dynamo in order to understand the significance for the world of the release of heat energy or of the generation of electrical energy. Why, then, do we fall into the error of believing that we must

understand completely the scientific nature of cyclotrons, betatrons, and the process of radio-activity in order to determine how the release of atomic energy is to be used by the world?"

From a total of fifty-two questionnaires, a response of sixty per cent was received. While it is unquestionably an assumption to conclude that no response probably indicates a lack of activity in the field of atomic energy education on the part of the institution contacted, it is probably a valid conclusion to make in light of such comments as "we haven't been particularly energetic in this respect, so we can report nothing new," which were mentioned in several instances.

After a consideration of the above data, the following conclusions seem valid:

1. In ninety-five per cent of the institutions reporting, there was some attempt to include atomic energy education in the total teacher-training curriculum.
2. Sixty per cent of the institutions which indicated they made some attempt to include atomic energy education in their teacher-training program, indicated that at least one course, dealing in part with atomic energy, was required of all students.
3. The remaining forty per cent of the reporting colleges and universities indicated that the prospective teacher had the opportunity to study atomic energy through elective courses which dealt, at least in part, with the facts and implications of atomic energy.
4. In terms of specific courses which deal exclusively with atomic energy, there are very few currently offered by teacher-training institutions in the United States. There were no such courses reported at the undergraduate level.
5. Of the institutions reporting some atomic energy education in their programs, thirty per cent indicated that this phase of the total curriculum was dealt with in professional education courses, as well as in science courses.
6. The amount of atomic energy education received by future teachers seems to be dependent upon two factors:
   a. The science courses elected by the prospective teacher.
   b. The emphasis placed upon atomic energy by individual instructors and/or courses.
7. At present, according to the data received in this survey, sixty per cent of the atomic energy educational programs reported to the Atomic Energy Commission in the years 1947–1950, for teacher education, have been modified. The remaining forty per cent remain substantially the same.
8. The colleges and universities which modified their programs dropped the workshops and institutes from their programs.
9. The curriculum changes proposed consisted of "integrating" atomic energy education with existing courses in the teacher-training program.
10. There is no clear-cut, over-all program for atomic energy education reported by the teacher-training institutions polled.
11. While an "integrated" program of atomic energy education seems to be advocated by the majority of institutions replying, there is considerable disagreement as to how this "integrated" program is to operate in actual practice.

AUDIO-VISUAL RESOURCES FOR THE TEACHING OF SCIENCE *

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I. PURPOSE OF THE STUDY

THIS study attempted to produce a realistic basis for enrichment of the general science program offered in a typical junior high school. In attempting to meet this general objective, four definite purposes were set up:

1. To determine the current objectives for the teaching of general science.
2. To discover the specific interests of pupils in the major areas of science.
3. To develop criteria for selection and techniques of utilization of audio-visual instructional materials in the science curriculum.
4. To integrate a comprehensive list of selected audio-visual resources into the science program.

* Paper presented at the Twenty-fifth Annual Meeting of The National Association for Research in Science Teaching, Congress Hotel, Chicago, Illinois, February 15, 1952. Based on the author's unpublished doctoral dissertation, University of Denver, 1951.

II. Philosophy of tue Study

The introduction of general science into the curriculum came with the development of the junior high school movement. While most of the junior high school subjects were, in most cases, adapted bodily from the elementary school or the high school, general science had no such predetermined form or content. Numerous curricular studies have been carried out by serious workers in an attempt to discover the aim and scope of general science teaching.

With the change in the conception of the place of the junior high school from that of a preparation for the senior high school to one in which the child, his needs, interests, and activities, came to be recognized as the logical factors to be studied in constructing the curriculum, came the realization that the junior high school had its own distinct and peculiar function in our educational organization. The thinking of science educators followed closely the above pattern. Once the needs of the pupils, as indicated by their interests and activities had been determined, a program for enriching and vitalizing their experiences in science could be contemplated.

Many fine investigations have been carried on having for their purpose the determination of the content for a course in general science. These studies have been largely from the teacher's and administrator's point of view, rather than that of the pupil's. Many of these studies have been concentrated on analyses of textbook or course of study content. In doing so, it seems, the fundamental problem of what the pupil thinks has been overlooked. Studies of the basic needs of pupils in approaching the study of science, and the adjustment of content to the varying interests of different levels of maturity, seem to be more basic than statistical studies concerned with the agreement or disagreement of content in the current textbooks or courses of study.

However, it should not be presumed from the above discussion that this investigator feels that the immediate interests of the pupils should be the only criterion for what is to be included in the curriculum. Pupils usually lack the mature judgments necessary to formulate a course of study. Most educators agree that merely because an activity looks good to a pupil at any given time, the results of that activity need not necessarily be profitable. Skilled guidance on the part of the teacher is necessary before these transient and momentary interests may be combined and organized so that important elements of our cultural heritage are not overlooked in developing the offerings in a particular course.

This study proposed to show how the methods and materials of audio-visual instruction might be used to enrich the teaching of general science. Once the needs and interests of the pupils have been determined, the skilled teacher can use this knowledge in the form of guides to help him determine the general organization of the course. Attention can then be focused on how careful selection and effective utilization of instructional aids may be made an integral part of the teaching procedure. It was hoped that this work would result in a practical guide which the teacher in the classrooms would find useful in his daily task of bringing the world to the child.

III. Delimitation of the Study

In attempting to delimit the scope of this study, the junior high school level was selected for several reasons. First, the science program on the elementary level, important as it is, cannot readily be separated as a program of studies apart from the other learning activities of the children. The current trend in educational thinking is towards the undepartmentalized elementary school. The interests of pupils in science at this level does present an interesting challenge, but since this investigation could not encompass the whole field of instruction, the elementary grades were not included.

The senior high school was not included because the offerings in science at this

level are pretty well set. A rather definite understanding has been reached by teachers at this level as to what areas and topics are to be considered in each major science class. Since, time, again, was a factor in this study, it was felt that the senior high school could not be included.

Second, the exploratory function of the junior high school has directed attention towards the interests of pupils from their own point of view. This experimental nature of the junior high school, and the fact that science teaching is a "natural" for the use of audio-visual materials, are two of the basic reasons for directing this study at that level and field of instruction. It seemed likely that an investigation into junior high school science teaching would produce rich and valuable results.

IV. Method of Procedure of the Study

The study was organized into four major parts. The first part dealt with the background of contributions of research to the field of science education. After establishing a brief historical link between present-day science teaching and the writings and philosophy of early educators influential in science education, a review of the different methods of curricular research carried on in this field was presented.

Since this study used an index of pupils' interests in science as a basis for integrating materials and methods for an enriched science program, a review of the main investigations dealing with science interests of pupils was presented. Each review gave the method used in the study and some of the significant findings. Because more than twenty major contributions in this particular area have been made since 1900, only a brief annotation of each investigation was included.

The second part of the study dealt with the construction, administration, and interpretation of a science interest questionnaire for junior high school pupils. It was felt that the various interest studies cited above did not give the necessary information desired for this study. As a basis for the construction of the questionnaire it was necessary to determine what the current objectives for general science teaching were. A survey was, therefore, made of the recommendations of national committees, authors of science education textbooks, selected state and city courses of study, and current literature. On the basis of these numerous statements, and from the experience of the investigator, five large objectives were synthesized as follows:

1. To develop understanding and insight into the forces and nature of the environment.
2. To develop knowledge and understanding of the facts, principles, and concepts of science.
3. To develop personal growth in the habits and methods of science.
4. To develop interests and appreciations in the benefits of science.
5. To develop democratic social attitudes towards the resources of science.

To select the 205 items which were included in the final questionnaire, a study was made of desirable understandings or outcomes listed in science education textbooks, selected courses of study, and in current literature. A total of 1071 statements were collected from the above sources. These were combined and reworded so that, with a number of contributions from the investigator's own experience, the total number of items was 305. This preliminary form was then submitted to a jury of teachers and to a jury of junior high school graduates. Each person checking this preliminary form was asked to select from the list, or add to the list, those items which he thought junior high school pupils would be interested in studying. On the basis of the highest average rankings from these preliminary returns, the 205 items for the final questionnaire were selected.

The final questionnaire was administered to a wide sampling of seventh, eighth, and ninth grade science pupils in Denver. A total of 486 completed returns were tabulated. Since each pupil checked each item as to whether he would like to learn about it, whether he was undecided, or whether he did not want to learn about it, a relative measure of the science interest in the areas covered was obtained. The resulting fre-

quency of likes and dislikes for each item was the basis for determining the topics and areas of science in which boys and girls at each grade level were interested in studying.

The third step in this study was to determine the criteria for selection and the principles of utilization of audio-visual instructional materials available to the teacher. This part was organized to deal with four major classifications of audio-visual aids: concrete instructional materials, pictorial instructional materials, graphic instructional materials, and auditory instructional materials. It was felt that each of these groups of instructional aids had certain unique teaching possibilities, and it was logical to develop a somewhat different methodology in the treatment of each group. These principles and criteria were generalized so that they could be applied to the selection and utilization of this group by teaching materials in any area of instruction in the curriculum. These were set up as guide posts which should be understood by every teacher using this class of instructional materials.

The final portion of the dissertation attempted to integrate the audio-visual instructional materials commonly available into a topical organization of a general science program. Based upon the areas of interest which the pupils expressed at each of the grade levels, materials of instruction, selected according to the criteria mentioned above, were suggested. It was realized that no teacher would probably have the facilities, or the time, to utilize all the audio-visual material suggested. Rather, it was the aim in this part of the study to offer a broad group of resource material from which each teacher would be able to select that part most suited to the interests and needs of his particular class.

A number of short articles have been published in current educational journals based on specific areas of the dissertation. These are as follows:

1. Sam S. Blanc, "Science Interests of Junior High School Pupils," *School Science and Mathematics*, 51:745–52, December, 1951.
2. ———, "Instructional Materials for Astronomy and Geology," *The Science Teacher*, 18:296–98, December, 1951.
3. ———, "Selection of Audio Instructional Materials," *Audio-Visual Guide*, 18:11–13, January, 1952.
4. ———, "Review of the General Goals of Science Teaching," *Science Education*, 36:47–52, February, 1952.
5. ———, "Development of Science Teaching in the Junior High School," *Science Education*, 36:107–113, March, 1952.
6. ———, "Instructional Materials for the Physical Sciences," *The Science Teacher*, 19:63–66, March, 1952.
7. ———, "Vitalizing the Classroom," *Educational Leadership*, 9:444–47, April, 1952.
8. ———, "Science Instruction Through Three-Dimensional Devices," *The School Executive*, 71:64–66, May, 1952.

SCIENCE INTERESTS OF JUNIOR COLLEGE GIRLS AS DETERMINED BY THEIR READINGS IN CURRENT SCIENCE *

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THE purpose of the study may be expressed in three parts: (1) to determine the areas of science interests of junior college girls, (2) to determine the sources from which they read, and (3) to determine the nature of a science course built upon the interests as expressed in the readings of the girls.

Method of Research: Examination was made of the 10,215 reading reports made by the 217 Stephens College girls from the basic science course who participated in the study. The reports were analyzed to

* Paper presented at the Twenty-fifth Annual Meeting of The National Association for Research in Science Teaching, Congress Hotel, Chicago, Illinois, February 14, 1952.

TABLE I

NUMBER OF DIFFERENT SOURCES USED BY GIRLS IN DIFFERENT GROUPS
66

Group	Number of Girls	Articles	Range of Sources *	Cards Giving No Source
I.	20	676	59	4
II.	20	598	43	2
III.	20	1,313	55	0
IV.	22	722	50	4
V.	135	6,906	99	261
Totals	217	10,215		271

* Represented in the total 115 sources used in study.

TABLE II

TEN MOST POPULAR SOURCES OF SCIENCE ARTICLES READ BY STUDENTS OF GENERAL BIOLOGY

Sources	Total Number of Reports	Percentage of Total	Rank in Total Reading List
Time	2,829	27.7	1
Science Digest	1,079	10.6	2
Reader's Digest	723	7.1	3
Life	687	6.7	4
Science Newsletter	545	5.3	5
Science Illustrated *	485	4.7	6
Newsweek	417	4.1	7
Today's Health **	411	4.0	8
Newspapers	235	2.3	9
Good Housekeeping	203	2.0	10
Totals	7,614	74.5	

* Publication discontinued in 1949.
** Name changed from *Hygeia* to *Today's Health* in 1950.

TABLE III

LARGE AREAS OF SCIENCE REPRESENTED IN TOTAL READINGS OF JUNIOR COLLEGE GIRLS

Science Areas	Number of Articles	Percentage of Total
Biological Science	6,620	64.8
Physical Science	2,801	27.4
Biological-Physical	478	4.7
Social Applications of Science	317	3.1
Total	10,215	100.0

determine the source of each reading report, and to find into which of the twenty interest categories that were derived each reading report should be classified. On the basis of marks obtained in General Biology, the basic science course, groups of students of varying abilities were established to find what influence high, low, or median ability had on the science interests and the selection of reading courses.

Tables were constructed to show the frequency of use of sources of various types and to show the distribution of interests in twenty categories.

A course outline was made to illustrate the nature of a science course built on interests as expressed in the readings of the girls.

Summary:

1. The science interests of junior college girls are largely in the biological sciences.

2. The interests of the girls are not concerned with the biological field as a whole but are primarily concerned with "homocentric biology."

3. The interests of the girls are not in technical science but in non-technical science.

4. The interests of the girls are low in many of the science areas which are commonly assumed as necessary for general education.

5. There are few interests of the students with high marks that are not shared by those girls with low marks.

6. The junior college girls depend more upon the current news type magazines and in particular those sections of such magazines devoted to "Science" and "Medicine" for their science reading than upon any other type of magazine.

7. The junior college girls tend to read mostly from digests and magazines which present short, concise articles.

8. Technical science publications have little attraction for the junior college girls of the study.

9. The magazines directed especially toward women readers supply relatively few science articles which are read by junior college girls.

10. Junior college girls with the highest

TABLE IV

GENERAL CLASSIFICATION OF SCIENCE REPRESENTED BY READING OF SELECTED JUNIOR COLLEGE GIRLS

Aspect of Science	Number of Reports	Percentage of Total	Rank in Total Study
Biological Aspect			
Health and Disease	2,267	22.2	1
Medicine and Drugs	1,855	18.2	2
Zoology	505	4.9	6
Physiology and Anatomy	1,102	10.8	3
Agriculture	384	3.8	8
Botany	188	1.8	14
Heredity and Genetics	206	2.0	13
Anthropology	113	1.1	17
Sub-Total	6,620	64.8	
Physical Aspect			
Physics	954	9.3	4
Chemistry	412	4.0	7
Earth Science	508	5.0	5
Atomic Energy	334	3.3	10
Astronomy	380	3.7	9
Aviation	213	2.1	12
Sub-Total	2,801	27.4	
Biological-Physical Aspect			
Science of Homemaking	294	2.9	11
Conservation	80	0.8	18
Nature Study & Recreation	76	0.7	19
Archeology	28	0.3	20
Sub-Total	478	4.7	
Social Aspects			
Science Education	181	1.8	15
Science and Social Problems	135	1.3	16
Sub-Total	316	3.1	
Total	10,215	100.0	

marks in General Biology read from a greater variety of publications than do those with low marks.

11. The interests of girls of varying abilities are so much alike that differences in interests need not be taken into consideration in setting up a terminal science course that would appeal to the whole group.

12. The interests of the girls as expressed in their science readings are in the results of the works of the scientists rather than in scientific methodology.

13. The interests of the girls are primarily in those phases of science that have a direct relationship to themselves or to mankind.

14. A science course which might be built upon the categories in which the highest interests were expressed may be inadequate to meet the needs of a general education science course.

Recommendations:

1. Other corroborative investigations similar to the present study but using different techniques, to determine the interest of junior college girls.

2. A comparable study for men of the junior college age to determine if there are sex differences in the interests in science.

3. A breakdown of the large interest areas of Health and Disease, Medicine and Drugs, and Physiology and Anatomy (a)

to find the problems of health for which junior college girls seek answers, (b) to find the interests of junior college girls concerning diseases, and (c) to find the particular diseases in which junior college girls are interested.

4. Investigation to determine methods of strengthening interests in the areas in which the interests of junior college girls are low.

5. An analysis of current magazines to determine their science content for comparison with the older studies.

6. An investigation of the scientific reliability of the science articles in the general magazines widely read by students and adults.

7. An investigation of the possibility of organizing and teaching a general education course based on the science materials in the general and non-technical science magazines.

8. A comparison of the understanding of scientific methodology and attitudes of students in a general education science course when the course is based on materials taken from current science literature, with students taught in a survey course with traditional textbooks, materials, and methods.

PERFORMANCE TESTS IN PHYSICS AT THE UNIVERSITY OF MINNESOTA *

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1. *Introduction*

A CONSIDERABLE number of studies in science education have compared the outcomes of instruction by lecture-demonstration with the individual-laboratory method. Cunningham[1] examined and evaluated 37 investigations dealing with the above problem, but he could not make a clear-cut decision regarding the relative merits of the two methods. Inadequate experimental design in many of the studies, the obsolete statistical techniques used, the limitations of the evaluating insruments, the hazy formulation of the problem, and the insufficient description of the procedure —all point to the need of additional research.

The outcomes of laboratory instruction are of special interest and importance in the elementary college physics science courses. Much time, energy, building space, personnel and money is directed toward the organization of the instructional laboratories, yet reliable studies as to the most effective teaching and equipment methods are practically nonexistent.

2. *The Problem and Its Significance*

The present learning experiment was designed as a pilot study to measure differences in effectiveness between two methods of teaching laboratory physics at the college level. One method was the conventional type of physics laboratory situation in which students worked in pairs with a complete set of equipment for the assigned experiment. The students arranged and

* Paper presented at the Twenty-fifth annual meeting of The National Association for Research in Science Teaching meeting, Congress Hotel, Chicago, Illinois, February 15, 1952. The study was sponsored and supported in part by the Committee on Institutional Research, University of Minnesota, through the Bureau of Institutional Research.

** Now at the University of Alabama, University, Alabama.

[1] Cunningham, Harry A. "Lecture Demonstration Versus Individual Laboratory Method in Science Teaching." *Science Education,* 30:70–82, March, 1946.

manipulated the apparatus, collected and recorded data, wrote a report and submitted it for grading. The instructor was on hand to help in case of difficulty during the progress of the work. In the demonstration method only one set of equipment was provided for the entire laboratory group, with the instructor performing as a demonstrator. The instructor assembled and adjusted the equipment, made the readings and organized the data, which were used in the computations of results. A further description of the methods used to instruct these experimental sections is given later.

Essentially the problem was reduced to that of testing the following null hypothesis:

There is no difference in learning outcomes between students who perform conventional laboratory experiments in elementary physics and students for whom the same experiments are demonstrated by the laboratory instructor.

This experiment was undertaken primarily to obtain evidence as to the relative merit of the individualized laboratory and the demonstration methods of teaching college physics. It was also desired to make an evaluation of the achievement of specific outcomes of laboratory instruction by a systematic use of "practical," behavior-sampling type of tests in addition to pencil-paper examinations.

3. *Population*

The experimental and the control groups were drawn from students enrolled in Physics 2 and Physics 2a, Winter quarter 1950, at the University of Minnesota.

Physics 1, 2, 3, *Introduction to Physical Science,* is "a course designed for those who wish a general cultural introduction to physics but do not plan to major in that subject."[2] This sequence (3 quarters, 9 credits) is offered without laboratory. This course is required of majors in architecture, medical technology, and physical therapy.

Students in Physics 1a, 2a, 3a (3 quarters, 12 credits) cover the same subject matter as those in Physics 1, 2, 3, but take laboratory in addition to fulfill the laboratory-science group requirement in science, literature and the arts.[3] This sequence is required of majors in pharmacy, predental students and prospective high school science teachers (without a major in physics and chemistry). Premedical students and those majoring in Physics, Chemistry, Mathematics and Engineering cannot take these courses for credit. One year of high school algebra and plane geometry are prerequisites for both courses.

The enrollment during the quarter under study totalled 300 students with 165 registered for laboratory. The large majority of students were male with only 40, or less than one out of seven, women enrolled.

4. *The Design and Procedure of the Experiment*

In order to attain the prerequisites of a self-contained experiment, a simple 2×2 design was used. Two instructors were selected with each assigned two sections. In his control section each instructor taught by the conventional method as described below, while in the experimental section only the demonstration method was utilized. In this manner the criteria of control and replication were achieved. The analysis of variance technique was used to test the effect of interaction of different instructors and the interaction between one instructor and either of the two methods.

Practical difficulties made it impossible to randomly assign all of the 165 laboratory students in the population. Control factors made it necessary to use students available on the same day of the week and the 2×2 design necessitated a morning and afternoon section for each of the instructors. Even after the random assignment of the limited number which resulted, cancellations and other factors resulted in

[2] The Bulletin of the University of Minnesota, The College of Science, Literature and the Arts, 1949–1950, Volume 52, No. 12, March 29, 1949, page 118.

[3] *Ibid.*

complete data being available for only thirty-eight students. There were ten and nine students in the morning experimental and control groups respectively, with eleven and eight in the corresponding afternoon groups. There is no evidence as to the bias which might have resulted from the population losses.

This study is unique in that it includes not only control groups which have been subjected to the conventional laboratory instructions, but also a zero control group which had no laboratory experience to supplement the regular course work. There were 135 students enrolled without laboratory work. The zero control group was randomly selected from those available on the same day as the experimental and control groups. Forty were thus selected and induced to participate in the testing programs. Thirty-five took the pre-tests but only twenty-one eventually completed the testing program and were given a ten per cent increase in their grade as compensation for their time and effort.

The samples were homogeneous to the extent that every student selected for the study was a Minnesota high school graduate, had a home address in the continental U.S.A., had a score on a college aptitude test, and had completed Physics 1 or 1a at the University of Minnesota with a grade of D or better. Of the two graduate assistants selected as instructors for the four laboratory sections, one was considered by his supervisors to be a better than average instructor; the other assistant a very superior teacher. The two assistants tossed a coin to determine which one would teach the experimental group in the morning.

The control factors for the experimental, control and zero control groups can be enumerated as follows:

1. The three lectures per week were the same. Although no attendance was taken, there was no reason to suspect that one group would have a better attendance record than any other group.
2. The textbooks and the assignments were the same.
3. The tests given as pre-tests and post-tests were identical. The regular course examinations were identical.
4. An equal number of clock hours in the laboratory was spent by the experimental and control groups (but none by the zero control group).
5. The subject matter was held constant for the experimental and control groups. The same experiments with the same equipment and laboratory manual were performed.
6. The laboratories met on Thursday of each week. If the experiment came before or after the theory had been covered in the lectures, the relationship was the same for the control as well as the experimental sections.
7. A short quiz covering some aspect of the theory of the experiment was given near the start of each laboratory period. This served to hold relatively constant the amount of preparation students made before coming to the laboratory class. It was felt that students who were not responsible for performing the experiment individually might otherwise have come unprepared.
8. One experimental and one control group was taught by each of the two laboratory instructors.

The experimental and control groups were subjected to a contrasting treatment in the laboratory. In the experimental groups the instructors performed the experiment. The instructors did all the wiring, meter reading, rheostat adjusting, etc. The students observed the technique used, examined the apparatus components, watched for observable phenomena, but did not manipulate, nor assemble, nor adjust any of the apparatus. Instructors were told to hold all apparatus up for identification and discussion and the small size of the groups made it possible for students to have an unobstructed view of the equipment. Students were encouraged to ask questions and to participate in the discussion. Data tables were drawn on the blackboard by the instructor, but in some cases a student acted as recorder while the instructor was making observations. Students were permitted to take some of the readings but the data used for computations was verified by the instructor. The students worked on the data outside of class, or in class if time permitted, and submitted a written report as required in the conventional laboratory. Students in the demonstration sections were aware that the method was unique and undergoing a test. All had been familiar with the conventional methods of laboratory instruction during the previous quarter of work.

The students in the control groups performed the assigned experiments in groups of two. Assembly and adjustment of apparatus was done by the students, as in the conventional laboratory method. The data were taken home by the student; a laboratory report written outside the laboratory was required.

5. *Questionnaires, Tests and other Evaluation Measures*

During the first day in class the students were asked to fill out a special information form, which served as a basis for the selection of the samples and the assignment to the experimental and control groups.

The high school rank and the score on the ACE Psychological Examination was obtained from the Student Counseling Bureau.

All the students in Physics 2 and 2a were given a theory examination and a written laboratory test during the first two lecture periods.

The theory pretest consisted of 33 multiple choice items selected from the Cooperative Physics Test for College Students, Electricity—Forms C, D, E, and F. This examination was designed to measure the student's initial status with respect to facts, definitions, principles and applications of electricity and magnetism. The chosen items paralleled the contents of the course. The total administration time for this test was 50 minutes. The maximum possible score was 132 points.

The laboratory written test consisted of ten items, of which seven were of the multiple choice type, one laboratory problem, and two questions on circuit diagrams. The administration time for this test was 25 minutes. The maximum possible score was 10 points. One of the items is shown below.

( ) In a balanced Wheatstone bridge the most accurate results are obtained when
- (a) the slider contact is near the end closest to the unknown resistance
- (b) the slider contact is near the middle
- (c) the slider contact is near the end farthest from the unknown resistance
- (d) the current in the slide wire is small
- (e) the slide-wire is exactly one meter long

The experimental control and zero control groups were also given two "practical"-performance-pretests in the laboratory.[4] The items in these examinations involved observation, selection, manipulation, and assembly of laboratory apparatus. The student entered the data, diagrams, calculations, etc. into a special examination booklet.

The short-item performance examination was designed to measure some basic instrumental skills, skills in the use of the controlled experiment, circuit tracing and assembly, and functional understanding of principles. Students moved at 4-minute intervals from one "station" to the next on a signal from the instructor. This test consisted of 14 items. The maximum possible score was 140 points. A typical item is reproduced below.

LOCATION 76

GIVEN: A simple circuit consisting of a battery, resistance, and an unknown element in a box. A voltmeter and a pair pair of leads are also supplied. DO NOT DISTURB THE CIRCUIT.

PROBLEM: By using the voltmeter, determine whether the battery is being *discharged or charged*. Indicate briefly the basis for your decision.

The long-item practical laboratory performance test was designed to measure skill in solving more complex problems involving the use of laboratory apparatus. The test consisted of four problems, with 13 minutes allowed for the completion of each item. One of the problems is shown on the following page.

[4] It is necessary to make some of the practical items as tamper-proof as possible. Abundant use of scotch tape, plastic covers, and similar protection devices reduce the hazard of item invalidation through student disregard of precautions, or failure to read directions. Thus, the original short-item test contained 16 items, but two of them became worthless sometime during the test administration because the setting of two instruments was changed by examinees, either intentionally or unintentionally.

LOCATION 34

GIVEN: 0–3 voltmeter, dry cell, decade resistance box

PROBLEM: To construct a 0–6 voltmeter by using the decade resistance box as an auxiliary component of the voltmeter.
- (a) Draw the circuit you used.
- (b) Indicate the method you used including the final reading of the decade box.
- (c) Disconnect your circuit before leaving the location.

MOVE TO LOCATION 35 when instructor signals.

The final tests were the same as the pretests. An additional test was constructed and administered as part of the final written examination. Ten items from the fourteen item practical were converted into a pencil-paper form. The formulation of the item was preserved and the apparatus drawings and wiring were made to look as much as possible like the original laboratory setups. Several members of the Physics Department were satisfied with the face validity of all the tests used. The reliabilities are given in the section on *Analysis of Data*. In addition to the objective comparison between methods and instructors, a student evaluation of the instructors was obtained. The classes were also visited several times by professional observers.

6. *Analysis of Data*

The findings concerning the course tests built for this study are presented first. Secondly, the data are analyzed to compare the selected samples with each other and with the other members of the class. The next section presents the findings concerning the basic hypothesis of no difference between the different methods of instruction or the different instructors. Then the gains of the zero control group who had no laboratory instruction are compared with those who had such instruction. Findings from the instructor and method evaluation

TABLE 1

BASIC TEST DATA FOR THE EXPERIMENTAL AND CONTROL GROUPS

Test	Group	Range Pre-test	Range Post-test	Means Pre-test	Means Post-test	Standard Deviations Pre-test	Standard Deviations Post-test
Theory	Control (N=17) (C_1, C_2)	0–80	26–108	27.17	69.72	22.66	24.77
	Experimental (E_1, E_2) (N=21)	0–67	23–94	14.36	55.32	15.35	18.47
	Instructor A (N=19)	14–67	23–103	25.17	66.28	19.89	24.76
	Instructor B (N=19)	0–80	26–108	16.36	58.76	19.26	20.02
Laboratory Written	Control	0–3	2–9	1.292	6.540	1.16	1.69
	Experimental	0–5	3–9	0.918	5.427	1.18	2.11
	Instructor A	0–5	3–9	1.266	6.311	1.28	2.13
	Instructor B	0–3	2–9	0.943	5.656	1.05	1.57
Long-item "practical" laboratory performance	Control	0–65	0–100	18.13	52.95	21.49	31.20
	Experimental	0–60	0–90	8.41	29.16	18.24	34.31
	Instructor A	0–65	0–90	15.00	44.64	21.85	35.83
	Instructor B	0–60	0–100	11.53	37.47	18.71	34.33
Short-item "practical" laboratory performance	Control	0–87	39–101	33.24	70.97	21.54	17.18
	Experimental	3–59	18–79	26.08	56.66	15.75	16.79
	Instructor A	3–65	38–101	32.01	69.47	17.84	15.39
	Instructor B	0–87	18–93	27.31	58.16	19.66	19.57

Groups C_1 and C_2 with nine and eight members respectively made up the control method. Groups E_1 and E_2 had ten and eleven members respectively. Groups C_1 and E_1 were assigned to Instructor A; Groups C_2 and E_2 to Instructor B.

by students are summarized. Finally, there is reported the results of an auxiliary study to find the correlations between scores on ten practical test items and similar test items in the pencil-paper examination.

A. *Data Concerning the Tests Used*

The basic test data for the experimental and control groups are presented in Table 1. Inspection of the data shows a large and significant difference between the means of every post-test and the corresponding pre-test. The upper limit of the scores on all the post-tests exceeded the same limit for the pre-tests; the same fact was true for the lower score limits, with the exception of the long-item practical laboratory test. There were so many zero scores on the latter test that the standard deviations for it are probably not too meaningful.

The Hoyt analysis of variance method [5] was used to obtain an index of the reliability of the tests used. The computations were made on the data from the thirty-eight individuals in the four selected groups. With the Hoyt method a reliability coefficient is obtained and the F ratio can be computed to test the hypothesis that there is no difference between the means of individuals. If the F ratio is significant, it may be concluded that the test measures sufficiently accurately to differentiate among individuals. The values obtained from this analysis are recorded in Table 2. All the variance ratios are significant and the hypothesis of no differentiation among individuals is rejected.

The low reliabilities of the three laboratory tests might be attributed to the fact that these measuring instruments sampled a variety of skills and aptitudes, rather than a single trait.

The subjective element in the scoring of the practical examinations was reduced by the use of a very detailed key. The two participating instructors scored all of the practical papers. To test the reliability of scoring, the two instructors graded independently the long-item and the short-item practical pretests of twenty-three students. An analysis of variance based on the total scores showed no significant difference between the grades of the two instructors.

Zero order correlations between the initial measures and achievement criteria were calculated for the thirty-eight selected individuals. The correlation coefficients, reproduced in Table 3, were used as a guide to a more elaborate analysis.

The low cerrelations between the ACE scores and the grades on the theory and laboratory written examination are not surprising since the ACE examination is a relatively inefficient predictor of achievement in physics.[6] The relatively high correlation between the ACE and the long-

[5] Hoyt, Cyril J. "Test Reliability Estimated By Analysis of Variance." *Psychometrica,* 6: 153–160, June, 1941.

[6] Kruglak, Haym and Keller, Robert J., "The Prediction of Achievement in Sophomore Engineering Physics," *Am. J. Phys.* 18:140–146, March, 1950.

TABLE 2

RELIABILITIES AND BETWEEN INDIVIDUAL VARIANCE RATIOS OF THE FOUR CRITERION PHYSICS TESTS USED AS PRE- AND POST-TESTS COMPUTED BY THE HOYT ANALYSIS OF VARIANCE METHOD

Test	Pre-Test r	Pre-Test F	Post-Test r	Post-Test F
Written Laboratory (10 items)	.400	1.66*	.538	2.16**
Four Item Practical	.435	2.16**	.490	2.54**
Fourteen Item Practical	.647	2.84**	.428	1.75**
Theory Test (33 Items)	.760	4.10**	.732	3.73**

** Significant at the 1 per cent level.
* Significant at the 5 per cent level.

TABLE 3

ZERO ORDER CORRELATION COEFFICIENTS BETWEEN INITIAL MEASURES AND ACHIEVEMENT CRITERIA

Achievement Criteria / Initial Measures	Correlation Coefficients: Theory Test	Laboratory Written Test	Long-Item Lab. Practical Test	Short-Item Lab. Practical Test
ACE Psychological Examination	.346*	.369*	.640**	.196
Previous Physics Grade	.753**	.569**	.528**	.572**
Theory Pre-test	.691**	.323*	.474**	.610**
Lab. Written Pre-test	.432**	.238	.422*	.538**
Long-Item Practical Lab. Performance Pre-Test	.468**	.265	.595**	.582**
Short-Item Practical Lab. Performance Pre-Test	.565**	.253	.474**	.612**

Correlation between ACE and previous physics grade, $r = .280$.
** Significant at the one per cent level.
* Significant at the five per cent level.

item practical test indicates the insight nature of the test items. The very low and non-significant coefficient between the ACE and the short-item practical test points up the non-verbal, instrumental aspect of the test items. The highest correlation was found between the previous physics grade and the theory test. This result can be best explained by pointing out the fact that the previous physics grade was based largely on tests which were technically similar to the theory test, and which sampled similar types of skills. Since all of the coefficients between the previous physics grade and the criteria were greater than 0.50 and significant at the one per cent level, the analysis of covariance with the previous grade held constant was indicated. The correlations between the pre-tests and the corresponding post-tests were also greater than 0.50 and significant at the one per cent level, with the exception of the laboratory written test. Consequently, an analysis of covariance with the effects of the pre-test partialled out was carried out.

TABLE 4

INTERCORRELATION MATRIX BETWEEN INITIAL MEASURES

	Previous Physics Grade	Theory Test	Laboratory Written Test	Long-Item Lab. Practical Test	Short-Item Lab. Practical Test
ACE	.280	.374*	.253	.541**	.374*
Previous Physics Grade		.784**	.417**	.427**	.626**

** Significant at the 1 per cent level
* Significant at the 5 per cent level

TABLE 5

INTERCORRELATION MATRIX FOR POST-TEST SCORES

Test	Long-Item Lab. Practical Test	Short-Item Lab. Practical Test	Laboratory Written Test
Theory	.515**	.522**	.514**
Lab. Long-Item		.361*	.518**
Lab. Short-Item			.412*

** Significant at the 1 per cent level
* Significant at the 5 per cent level

TABLE 6

Summary of Testing Interaction and the Hypothesis of No Difference on Initial Measures for the Experimental and Control Groups

(N = 38)

Initial Measure	Method of Analysis	Initial Measures Held Constant	Conclusion		
			Interaction	Between Methods	Between Instructors
ACE Psychological Examination	Variance		Not signif.	No diff.	No diff.
Previous Physics Grade	Variance		Not signif.	Region of doubt	No diff.
Theory Pre-test	Variance		Not signif.	Region of doubt	No diff.
Theory Pre-test	Covariance	ACE	Not signif.	Region of doubt	Region of doubt
Theory Pre-test	Covariance	Previous Physics Grade	Not signif.	No diff.	No diff.
Laboratory Written Pre-test	Variance		Not signif.	No diff.	No diff.
Laboratory Written Pre-test	Covariance	ACE	Not signif.	No diff.	No diff.
Long-Item Practical Lab. Performance Test	Variance		Not signif.	No diff.	No diff.
Long-Item Practical Lab. Performance Test	Covariance	ACE	Not signif.	No diff.	No diff.
Short-Item Practical Lab. Performance Test	Variance		Not signif.	No diff.	No diff.
Short-Item Practical Lab. Performance Test	Covariance	ACE	Not signif.	No diff.	No diff.
Short-Item Practical Lab. Performance Test	Covariance	Previous Physics Grade	Not signif.	No diff.	No diff.

Another evidence of the low predictability of achievement by means of the ACE scores is the low and non-significant correlation between ACE and the previous physics grade.

The correlation between ACE and the long-item laboratory performance was .541, higher than the correlations between ACE and the other initial measures (see Table 4). The previous grade in physics correlated highly (.784) with the theory pre-test. This fact was also true for the theory post-test (See Table 3).

The intercorrelations between the post-test scores are given in Table 5. All of the correlation coefficients are positive and significant. However, the correlations are relatively low so that it is reasonable to assume that the four tests measured somewhat related but distinct outcomes.

B. *Comparative Ability of the Selected Groups*

It has been previously reported that complete test scores were available on thirty-eight individuals randomly assigned to the two instructors and two methods. The analysis of variance and covariance were used to compare the initial ability of these selected students and to test interaction. The results are summarized in Table 6. The interaction between instructor and method was not significant for the six initial measures. The differences were significant at the five per cent level on the theory-pre-test in favor of the conventional laboratory. Holding the ACE scores constant did not affect the level of significance on this test. However, when the effect of the previous physics grade was partialled out, the differences were no longer signifi-

cant. No significant differences were found on the theory pre-test between the two instructors. Holding ACE scores constant resulted in a difference at the five per cent level in favor of the conventional laboratory and instructor A.

Comparisons on the remaining five initial measures showed no significant differences between methods or instructors. Consequently, the assumption that the experimental and control groups were comparable in initial ability seemed justifiable.

The hypothesis of no difference on the six initial measures between the experimental-control, the zero control and the unselected laboratory group was also tested by the analysis of variance. Complete pre- and post-test data in the practical tests was obtained from forty-five students in the remaining group who took laboratory. There was complete information from an additional thirty-three students on the written laboratory and theory tests, ACE scores

TABLE 7

RESULTS OF TESTING BY ANALYSIS OF VARIANCE THE HYPOTHESIS OF NO DIFFERENCE ON THE INITIAL MEASURES BETWEEN THE EXPERIMENTAL-CONTROL GROUPS, THE ZERO CONTROL GROUP AND THE REMAINDER OF STUDENTS TAKING LABORATORY FOR CREDIT

Initial Measure	Groups Compared	N	Conclusion
ACE Psychological Examination	Experimental-Control Pooled $(E_1 + E_2 + C_1 + C_2)$	38	No difference
	Non-selected lab. group (R)	78	
ACE Psychological Examination	Experimental-Control Not Pooled (E_1, E_2, E_3, E_4)	10, 11, 9, 8	No difference
	Zero control (Co)	21	
ACE Psychological Examination	Experimental-Control Pooled $(E_1 + E_2 + C_1 + C_2)$	38	No difference
	Zero control (Co)	21	
Previous Physics Grade	$E_1 + E_2 + C_1 + C_2$	38	
	R	78	No difference
Previous Physics Grade	E_1, E_2, C_1, C_2	10, 11, 9, 8	
	Co	21	No difference
Previous Physics Grade	$E_1 + E_2 + C_1 + C_2$	38	
	Co	21	No difference
Theory Pre-Test	$E_1 + E_2 + C_1 + C_2$	38	
	R	78	No difference
Theory Pre-Test	$E_1 + E_2 + C_1 + C_2$	38	
	Co	21	No difference
Laboratory Written Pre-Test	$E_1 + E_2 + C_1 + C_2$	38	
	R	78	No difference
Laboratory Written Pre-Test	E_1, E_2, C_1, C_2	10, 11, 9, 8	
	Co	21	No difference
Laboratory Written Pre-Test	$E_1 + E_2 + C_1 + C_2$	38	
	Co	21	No difference
Long-Item Practical Lab. Performance Pre-Test	$E_1 + E_2 + C_1 + C_2$	38	
	R	45	No difference
Long-Item Practical Lab. Performance Pre-Test	E_1, E_2, C_1, C_2	10, 11, 9, 8	
	Co	21	No difference
Long-Item Practical Lab. Performance Pre-Test	$E_1 + E_2 + C_1 + C_2$	38	No difference
	Co	21	
Short-Item Practical Lab. Performance Test	$E_1 + E_2 + C_1 + C_2$	38	
	R	45	No difference
Short-Item Practical Lab. Performance Test	$E_1 + E_2 + C_1 + C_2$	38	
	Co	21	No difference

and final physics grades for previous quarter.

The results of the findings, shown in Table 7, indicate that the thirty-eight students in the experimental-control groups were comparable in ability and background to the zero control group and to the non-selected group taking laboratory for credit. The selected group appeared to be a representative sample of the total laboratory population.

C. *Comparison of Methods and Instructors*

The analysis of variance and covariance to test the hypothesis of no difference between the methods of instruction and between the instructors was made for each of the four criterion post-tests. The post-tests were identical with the pre-tests. There was probably very little practice effect, since none of the test items were used for instructional or test purposes during the course; nor did the students know that the same items were to be given as post-tests.

The basic hypothesis of the study was tested by the analysis of variance, by the analysis of covariance with the pre-test held constant, and by the analysis of covariance with the pre-test and previous physics grade held constant. The results are summarized in Table 8.

No significant differences between methods or instructors were found on the theory test and the laboratory written test. The conventional method was found to be superior to the demonstration method at the five per cent level on the long-item practical test. However, the analysis of covari-

TABLE 8

SUMMARY OF TESTING THE HYPOTHESIS OF NO DIFFERENCE BETWEEN METHODS AND INSTRUCTORS FOR THE EXPERIMENTAL AND CONTROL GROUPS

Criterion	Method of Analysis	Initial measures held constant	Conclusion	
			Method	Instructor
Theory Test	Variance		No Difference	No Difference
Theory Test	Covariance	Pre-test	No Difference	No Difference
Theory Test	Covariance	Pre-test and Previous grade	No Difference	No Difference
Laboratory written test	Variance		No Difference	No Difference
Laboratory written test	Covariance	Pre-test	No Difference	No Difference
Laboratory written test	Covariance	Pre-test and Previous grade	No Difference	No Difference
Long-item "practical" lab. performance test	Variance		Control Superior 5% level	No Difference
Long-item "practical" lab. performance test	Covariance	Pre-test	Variances not homogeneous—statistical treatment inapplicable	
Long-item "practical" lab. performance test	Covariance	Pre-test and Previous grade	Variances not homogeneous—statistical treatment inapplicable	
Short-item "practical" lab. performance test	Variance		Control Superior 1% level	Instructor A Superior 5% level
Short-item "practical" lab. performance test	Covariance	Pre-test	Control Superior 5% level	Instructor A Superior 5% level
Short-item "practical" lab. performance test	Covariance	Pre-test and Previous grade	No Difference	No Difference

ance technique could not be used because the assumption of the variance homogeneity could not be met. From an inspection of the scores it appeared that the items on the long-item practical test were too difficult for the students in this particular course.

The conventional method was definitely superior to the demonstration when the analysis of variance was used on the short-item practical test. However, when the pre-test was held constant, the superiority was reduced from the one per cent level to the five per cent level. The differences disappeared entirely when the pre-test and the previous physics grade were partialled out. Instructor A was superior to instructor B on this test at the five per cent level. However, no significant differences were present when the pre-test and the previous physics grade were held constant. It is interesting to note that the four professional observers rated instructor A *inferior* to instructor B.

D. *Zero Control Group Achievement*

It has been previously shown that the zero control group did not differ in initial ability from the thirty-eight selected individuals (see Section B). This was true in ACE score, final physics grade in previous quarter, and the four pre-test scores. The analysis was then made on post-test scores holding pre-test constant. This procedure tested the hypothesis that there is no difference in achievement on the post-tests between the zero control group who had no laboratory instruction and the individuals who had such instruction. The selected groups were treated as one group who had the laboratory experience. The results of the analysis for all four course tests are reported in Table 9.

The results show a significant difference between the groups in all three tests which tested laboratory outcomes, but no significant difference on the theory test.

E. *Results of Student Evaluation*

Students were given an opportunity to react to their experiences in the demonstration and control sections, both in terms of the method and the instructor. A questionnaire was given to all students taking laboratory for credit. This questionnaire followed the pattern of the University of Minnesota, "Student Report on Classroom Teaching" with modifications to fit a laboratory section. The findings reported here are those from forty-six students [7] in the four sub-groups (E_1, E_2, C_1, and C_2) taking laboratory for credit.

Students in the demonstration sections were better satisfied than those in the control sections with the instructors' clarity of presentation, adjustment to their level of understanding, and tolerance for differences of opinion. Control section students rated their experiences higher in the amount of original thinking demanded, the interest of the work, and the extent to which the laboratory experience contrib-

[7] Forty-six was the number originally enrolled. Incomplete test data brought the number in the analysis down to thirty-eight.

TABLE 9

SUMMARY OF TESTING THE HYPOTHESIS OF NO DIFFERENCE IN ACHIEVEMENT BETWEEN THE EXPERIMENTAL-CONTROL GROUP ($N = 38$) AND THE ZERO CONTROL GROUP ($N = 21$)

Criterion	Method of Analysis	Initial Measures Held Constant	Conclusion
Theory Test	Covariance	Pre-test	No difference
Laboratory written test	"	"	Lab. group superior 1% level
Long-item "practical" lab. performance test	"	"	Lab. group superior 5% level
Short-item "practical" lab. performance test	"	"	Lab. group superior 1% level

uted to an understanding of lectures and the textbook readings. In general, the students of both sections did not feel that the laboratory contributed to such understanding.

The instructors were rated by their respective students and the qualities of both men became apparent. One instructor (B) received appreciably higher ratings on clarity of presentation, ability to adjust to the students' level, economical use of class time and clarity and audibility of speech. The other instructor excelled in his sense of humor, absence of annoying mannerisms, rapport with students and fairness in grading practices. The second was rated slightly higher in general teaching ability.

Students in the demonstration sections (N=25) were asked questions particularly focused on this method. All of these students had experienced the conventional method of laboratory instruction during the preceding fall quarter and were thus presumably capable of making comparisons.

More than half of those responding felt they had only casual or practically no opportunity to become acquainted with the apparatus. Approximately one-fourth expressed difficulty in following the demonstrations as presented. These students were quite well satisfied with the amount of time devoted to the theory of the experiment with most of the dissenters of the opinion that too much rather than too little time was thus utilized.

Two summary questions were asked of students in the demonstration (experimental) groups. The first question was: "In terms of the physics learned, how would you compare this demonstration method with a laboratory where you yourself could work the experiment with a laboratory partner?" Two-fifths felt more was learned when the instructor performs the experiment while 28 per cent felt they would learn more "when you do it yourself." Of the balance, one-half were undecided and a similar number did not respond. The second question asked for the student's preference as to type of method. Of those who answered the second question, 36 per cent favored the demonstration method, 16 per cent the conventional method and 32 per cent preferred no laboratory at all.

The instructors were also visited by observers from the Physics Department and the College of Education. These visits were made to insure the accomplishment of the intended design for the two methods.

E. *Practical Test Items Converted to a Pencil-Paper Test*

A sub-problem which was attacked in this study sought to measure the correlation between pupil's achievement on the same items presented in the contrasting situation of a practical laboratory test and a pencil-paper examination. As previously described, ten items from the fourteen item laboratory practical test were duplicated as nearly as possible as a part of the final examination. The problem situation was illustrated by complete apparatus drawings.

Data were obtained from all students who took both the laboratory practical post-test and the final examination for the course. This included the thirty-eight students selected for the contrasting methods of instruction, the balance of the class who took laboratory for credit and the zero control group. Table 10 reports the correlation

TABLE 10

CORRELATION BETWEEN SCORES ON TEN PRACTICAL LABORATORY ITEMS AND COMPARABLE ITEMS ADMINISTERED AS A WRITTEN FINAL EXAM

Student Groups	N	Correlation Coefficient
Experimental-Control	38	.556**
Balance of students taking laboratory	78	.409**
Zero Control	21	.712**
Total	137	.521**

** Significant at the 1 per cent level.

obtained for each of the three groups and for the total number of subjects. This result indicates that pencil and paper items

cannot be reliably substituted for some practical laboratory items even though they may be more convenient to construct and administer.

7. *Summary*

(1) The investigation dealt with the learning outcomes of laboratory instruction in the elementary, non-technical physics course in electricity and magnetism at the University of Minnesota, Winter Quarter, 1950.

(2) Two experimental and two control groups consisted of students taking the laboratory work for credit. One zero control group comprised students for whom the laboratory work was not required. The selection of individuals for the above five groups was made by the use of the random number technique.

(3) Six measures on the initial status of the selected individuals were obtained: first, score on the American Council on Education Psychological Examination; second, final physics grade for the preceding quarter; third, score on a pre-test in magnetism and electricity; fourth, score on a written laboratory examination; fifth, score on a long-item laboratory performance pre-test; and sixth, the score on a short-item laboratory performance pre-test.

(4) It was found that there were no statistically significant differences between the zero control group and the experimental and control groups on the six initial measures. There were also no differences on the same measures between experimental and control groups and the rest of the students who took laboratory for credit. Therefore, it was concluded that the five selected groups were representative of the course population.

(5) One experimental and one control group were assigned to each of two graduate assistants who acted as laboratory instructors. The zero control group took no laboratory, but attended the same lectures and took the same tests as the other groups. In the experimental groups all of the assigned experiments were demonstrated by the instructors. The students were not allowed to manipulate any of the equipment. In the control groups the students performed the experiments in the conventional manner: working in pairs from directions in a manual.

(6) The achievement criteria were the raw scores on the above-mentioned theory test and the three laboratory examinations, administered at the end of the quarter. The four tests had statistically significant reliability coefficients.

(7) It was found that there were no significant differences in grading reliability of the laboratory performance tests by two independent graders when a detailed scoring key was provided.

(8) The four laboratory groups were found to be superior to the no-laboratory group on the three tests dealing specifically with laboratory material. The effects of the pre-tests were held constant.

(9) There were no differences between the laboratory groups and the no-laboratory group on the theory test.

(10) No significant differences were found on the theory and laboratory written tests between methods of instruction or instructors.

(11) The conventional method was found to be superior to the demonstration method on the long-item practical laboratory examination. The covariance technique could not be applied to this test.

(12) The conventional laboratory method was found to be superior to the demonstration method on the short-item practical laboratory test with the pre-test held constant. There were no differences between methods of instruction when the effects of the pre-test and previous physics grade were partialled out.

(13) Instructor A was found to be superior to instructor B when the pre-test was held constant. The difference disappeared when the pre-test and previous grade were held constant.

(14) Ten of the items on the short-item

practical laboratory test were converted into an equivalent pencil-paper test. The correlation between the two sets of grades was positive, but *relatively low* (r=.52).

It is probable that a written test is not always, if ever, a substitute for a performance test.

(15) The results of this investigation point to the need of additional refinement of instruments for measuring specific laboratory outcomes.

(16) The investigation is being continued with a larger sample of students during the current quarter at the University of Minnesota.

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STUDIES IN MENTAL RIGIDITY AND THE SCIENTIFIC METHOD *

III Rigidity and Comprehensiveness in the Normal Classroom Situation

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In two previous papers [1, 2] mental rigidity and comprehensiveness were defined in operational terms. Rigidity was defined in the functional sense as sluggishness in variation of response, fixation of response, lack of variability, inability to change one's mental set when the objective conditions demand it, and inability to rearrange a mental field in which there are alternative solutions to a problem in order to solve that problem more efficiently [3]. In the first paper of this series [1] the following hypothesis was tested: Those individuals who manifest a rigidity of the thinking process will react differently to the various factors concerned with the scientific method than those who are relatively less rigid in their pattern of thinking. The hypothesis was tested by comparing the performance of the groups specified as rigid and non-rigid on a test made up of items concerning and testing various abilities implied in the scientific method. The results indicated that the hypothesis was confirmed.

The second paper of this series [2] dealt with the comprehensiveness of groups of persons in relation to their relative rigidity—non-rigidity of thinking. The comprehensiveness of an individual indicates that individual's ability to comprehend many things, to have a wide scope of thought, to have the ability to see broad and general relationships. The hypothesis tested was: Groups of individuals relatively less rigid in their thinking processes will exhibit a pattern of thinking that is more comprehensive than a group whose thought processes are more rigid and, con-

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sequently, whose patterns of thinking are more isolated and narrower. On the basis of the statistical analysis of the data obtained in the experiment on comprehensiveness the hypothesis was considered confirmed. The rigid individuals seemed to show an inability to go beyond the mere factual information at hand and to react on the basis of each individual fact separately. The individuals of the rigid group may even simply refuse to consider some of the facts that are at their command. The non-rigid individual, on the other hand, has the ability to see and to state the relationships existing and necessary for the correct solution of the problem. The data indicated that the comprehensive group of individuals can take the individual facts under consideration and organize them into a single unfied structure. The thought processes are broad and integrated and take all of the pertinent facts into consideration in arriving at a solution to the problem.

Following the testing and confirmation of the above two hypotheses it was decided to determine whether mental rigidity and comprehensiveness would be exhibited not only in the experimental situations but were actually part of a problem solving situation in the classroom. Therefore, the hypothesis tested was: The rigid personality structure and the comprehensive cognitive pattern will be found operative in a normal classroom situation which requires the use of the elements of the scientific method for the solution of a problem. This hypothesis was tested by comparing the performance of rigid and non-rigid groups, and groups showing comprehensive and non-comprehensive cognitive patterns on certain designated portions of an experimental laboratory study performed in the classroom.

Design and instructions for the study. The testing of this hypothesis was accomplished by comparing the performance of the above mentioned groups on a laboratory problem entitled, "Adjustment and Coordination in plants" [4]. In essence this problem deals with a series of rather simple experiments dealing with plant hormones and light in relationship to growth. The student usually comes to the laboratory with the preconceived idea that light aids plant growth directly with the result that plants grow more during the day than during the night. If the subject works through the study correctly he will come out with the information, based upon experimental results, that light inhibits growth (elongation) in plants. This should lead to the inference that plants grow more during the night than during the day.

The biologists who designed this laboratory exercise adapted the materials from the original experiments covering this phase of knowledge. This exercise was specifically designed as a study that deals with a series of simple experiments whose results can be utilized in the formulation, testing, and modification of hypotheses. It is considered that this study is one of the best laboratory exercises in the course of Basic Biological Science at Michigan State College for its assumed value in teaching the methods of science.

The introduction to the laboratory study being utilized in this report states that:

> There are certain areas in science where the thinking and experimental processes have been so clear and concise that they have become classics. . . . In this century some of the work on hormones has been of this type and will probably become classical as time passes.
>
> Our problem today deals with a series of rather simple experiments whose results can be used in the formulation, testing, and modification of hypotheses [4].

The specific factual information of this study has not been covered before in the classroom, but those aspects concerned with scientific methodology have been studied previously. The study, as has been noted above, deals with a number of experiments whose results can be utilized in the formulation, testing, and modification of hypotheses. This type of work has been part of the work in the laboratory portions of both the first and second terms of the course. There has been a constant and consistent effort made throughout the laboratory por-

tion of the course to inculcate the idea that the formulation, testing, and modification of hypotheses is one of the foremost aspects of the scientific method. There has been ample opportunity in all of the laboratory studies to practice this aspect of scientific methodology.

The conduct of the laboratory was as follows: There is one laboratory period per week which meets for two hours. Up to this point in the course the student has had thirteen laboratory studies. The laboratory class meets for two hours under the direction of a member of the staff of the Department of Biological Science. In this study, as in other studies, the student was given two hours to complete the problem. Ordinarily the instructor may assist or guide the student in the work of the day. However, in this particular study as part of the experiment, the students were asked to work through the study without assistance from the instructor.

Before beginning the study the subjects were asked to answer the following questions on a worksheet (Figure 1) before proceeding with the laboratory exercise, so as to discover and establish any preconceived ideas and factual information that the subjects may have pertaining to the study: (1) How do plants adjust and coordinate to the factors in the environment?; (2) Why do plants bend towards light?; and (3) Do plants grow more during the daytime or during the night-time? Why? Upon the completion of the answers to these questions the subjects then turned to the laboratory exercise. At the completion of the laboratory exercise the subject was again asked to answer some questions on a worksheet pertaining to the study (Figure 2). These questions were designed to gain knowledge as to: (1) the ability of the subject to work through the exercise and arrive at predetermined correct solutions; (2) the rejection or retention of preconceived ideas in light of new knowledge gained on the basis of experimentation; and (3) the ability of the student to judge correctly valid experiments and experimental results. The questions were as follows: (1) How do plants adjust and coordinate to the factors in the environment?; (2) Why do plants bend towards light?; (3) Do plants grow more during the daytime or during the night-time? Why?; (4) What is the relationship of light to growth in the higher green plants?; and (5) Do you consider that the series of experiments in this laboratory study are sound and valid and can be used to answer the above questions? Why? It was expected that, on the basis of the answers given to the foregoing sets of questions, some knowledge would be gained as to the performance of the subjects of the study in

Name ....
Instructor ....

Please answer the following questions to the best of your ability. This will in no way influence your grade in this course.

1. How do plants adjust and coordinate to the factors in the environment?

2. Why do plants bend towards light?

3. Do plants grow more during the daytime or during the night-time? Why?

FIGURE 1

WORK SHEET PERTAINING TO QUESTIONS ASKED PRIOR TO WORKING THE LABORATORY STUDY

Name ....
Instructor ....

Please answer the following questions to the best of your ability. This will in no way influence your grade in this course.

1. How do plants adjust and coordinate to the factors in the environment?

2. Why do plants bend towards light?

3. Do plants grow more during the daytime or during the night-time? Why?

4. What is the relationship of light to growth in the higher green plants?

5. Do you consider that the series of experiments in this laboratory study are sound and valid and can be used to answer the above questions? Why?

FIGURE 2

WORKSHEET PERTAINING TO QUESTIONS ASKED AFTER COMPLETION OF LABORATORY STUDY

relation to rigidity, and comprehensiveness of cognitive patterns.

Results. An important consideration in this portion of the work concerns the judgment of the answers given to the questions on the worksheets shown in Figures 1 and 2. The answers to all questions were judged by two biologists and complete agreement as to correctness of the answer was necessary on the part of the judges. In order to answer questions correctly the various factors of light, growth and bending of plants must have been taken into consideration by the student. The subject must have shown as complete an understanding of these factors as was possible on the basis of the knowledge gained in the study.

The first analyses of results were made to determine whether there existed any differences in the correctness of responses between the non-rigid and rigid groups and between the comprehensive and non-comprehensive groups to like questions on the work sheets: questions one, two, and three. (Figures 1 and 2). These questions were the same and so comparison could be made on a 'before' and 'after' basis. That is, before the beginning of the study and after the completion of the laboratory sudy. The following information was obtained and tabulated in Tables I, and II concerning the 'before' and 'after' responses to the question, "How do plants adjust and coordinate to the factors in the environment?" It can be seen from Table I that only eight of the rigid category of sixty-eight subjects and eleven of the non-rigid category of sixty-eight subjects were able to answer the question correctly. The chi-square of this difference is .548 with one degree of freedom and with significance at the 50% level. This is not considered a rejection of the null hypothesis and it was therefore inferred that on the basis of these results the two groups, rigid and non-rigid, are equal in their ability to answer the question correctly before working the laboratory study. A further study of Table I reveals that the rigid group of sixty-eight

TABLE I

Comparison of Rigid and Non-Rigid Groups as to Correctness of Response to Question One Before and After Completion of Laboratory Study

N Rigid 68 N Non-Rigid 68

	Before Study: Correct Responses	Before Study: Incorrect Responses	After Study: Correct Responses	After Study: Incorrect Responses
Rigid	8	60	33	35
Non-Rigid	11	57	43	25
X^2	.548		3.080	
Significance level	50%		10%	

TABLE II

Comparison of Comprehensive, Isolated, and Narrow Groups as to Correctness of Response to Question One Before and After Completion of the Laboratory Study

N Comprehensive 46 N Isolated 47 N Narrow 43

	Before Study: Correct Responses	Before Study: Incorrect Responses	After Study: Correct Responses	After Study: Incorrect Responses
Comprehensive	3	43	32	14
Isolated	2	45	24	23
Narrow	3	40	17	26
X^2	.359		8.2587	
Significance level	90%		2%	

subjects were able to give thirty-three correct responses, and the non-rigid subjects gave forty-three correct responses after finishing the study. The chi-square of this difference was 3.080 with one degree of freedom and with significance at the 10% level. This significance level is not enough to completely reject the null hypothesis, but indicates a trend towards rejection.

The second grouping, analyzed on the basis of the first question, concerned the comprehensive, isolated and narrow cognitive structures. A perusal of Table II showed that before the completion of the laboratory study three of the forty-six comprehensive subjects, two of the forty-seven isolated subjects, and three of the forty-three narrow subjects answered the question correctly. The chi-square of these differences amounted to .359 with two degrees of freedom and a significance level of 90%. This indicated retention of the null hypothesis. After the completion of the laboratory study the comprehensive group had the thirty-two correct responses, the isolated group twenty-four correct responses, and the narrow group had seventeen correct responses. This gave a chi-square of 8.2578 with two degrees of freedom and a significance level of 2%. The 2% significance level indicated a rejection of the null hypothesis and it was inferred that the difference is due to the greater comprehensiveness of the comprehensive group.

The next series of analyses concerned the second question, "Why do plants bend towards light? Table III gives the data showing the responses of the rigid and non-rigid groups of subjects. Two of the sixty-eight rigid and one of the sixty-eight non-rigid individuals gave a correct response before the beginning of the laboratory exercise. The chi-square of this difference was .338 with a significance level of 70%. After the completion of the laboratory study there were twenty-two rigid individuals and thirty non-rigid subjects

TABLE III

COMPARISON OF RIGID AND NON-RIGID GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION TWO BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Rigid 68 N Non-Rigid 68

	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Rigid	2	66	22	46
Non-Rigid	1	67	30	38
X^2	.338		1.990	
Significance level	70%		20%	

giving a correct response. The chi-square of this difference was 1.990 with a significance level of 20%. While this is not high enough for complete rejection of the null hypothesis, it does indicate a trend towards a significance level of some meaning. It might be inferred that while the rigid and non-rigid groups are equivalent in their ability to answer the question before the beginning of the laboratory exercise, the non-rigid group tends to do better than the rigid group after the completion of the study.

The performance of the comprehensive, isolated, and narrow groups on question two was without a significance level necessary for the rejection of the null hypothesis. A reading of Table IV will show that in each case, before and after the study the significance level reached was 50%, which is not enough to reject the null hypothesis, and it was inferred that the two groups showed equal ability to answer the question both before and after the working of the laboratory study.

The last analysis of this 'before' and 'after' series concerns the third question (Figures 1 and 2), "Do plants grow more during the daytime or during the nighttime? Why? The rigid and non-rigid groups before beginning the laboratory study were considered, as shown in Table V, to be equivalent on this question as the significance level of the difference of the correct responses was at the 70% level. The rigid group had one correct response out of sixty-eight subjects, and the non-rigid group had two correct responses out of sixty-eight subjects. The significance level of this difference was 70% and, therefore, the null hypothesis was retained. After the completion of the laboratory study the rigid group had seventeen correct responses, and the non-rigid group had twenty-eight correct responses. The chi-square of this difference was 4.016 and was significant at the 5% level. The null hypothesis was rejected at this level with the inference that the difference obtained

TABLE IV

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION TWO BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Comprehensive 46 N Isolated 47 N Narrow 43

	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Comprehensive	1	45	21	25
Isolated	0	47	16	31
Narrow	2	41	15	28
X^2	2.150		1.629	
Significance level	50%		50%	

TABLE V

COMPARISON OF THE RIGID AND NON-RIGID GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION THREE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Rigid 68 N Non-Rigid 68

	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Rigid	1	67	17	51
Non-Rigid	2	66	28	40
X^2	.338		4.016	
Significance level	70%		5%	

cannot be fully ascribed to chance or sampling fluctuations, but to the difference in the mental rigidity of the two groups.

The data on the comprehensive, isolated, and narrow groups for the before and after responses to the third question is presented in Table VI. There was no statistical difference in the number of correct responses given before the working of the laboratory study. The significance level was at the 99% level. However, at the completion of the exercise the comprehensive cognitive group had nineteen out of forty-six individuals give correct responses; the isolated cognitive group had seventeen out of forty-seven individuals give correct responses; and the narrow cognitive group had nine out of forty-three individuals give correct responses. The chi-square of these differences was 4.465 with a significance level of 20%. While this is not quite high enough to reject the null hypothesis completely, there is certainly indicated a trend in the hypothesized direction of rejection rather than toward retention of the null hypothesis.

TABLE VI

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION THREE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Comprehensive 46 N Isolated 47 N Narrow 43

	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Comprehensive	1	45	19	27
Isolated	1	46	17	30
Narrow	1	42	9	34
X^2	.003		4.465	
Significance level	99%		20%	

To summarize the 'before' and 'after' series, for which the statistical data has just been presented, it may be said that the data seem to indicate that in the case of the rigid and non-rigid groups there was a statistical trend in two of the questions towards a suitable significance level, and in one case there was rejection of the null hypothesis on the 5% level. In the case of the groups classified as comprehensive, isolated, and narrow in their cognitive structure, in one question there was no before and after difference shown statistically. In another question the significance level attained of 20% indicated a trend in the hypothesized direction. The third showed results at the 2% level indicating quite a decided difference between the comprehensive, isolated, and narrow groups, and this was in the hypothesized direction.

As it was not possible in this particular laboratory study to obtain information on all of the eighteen elements of the scientific method as previously listed [1], only a few were selected for study. It was possible to obtain information as to the ability

of the subjects to recognize a valid experiment when confronted by one. As heretofore stated, the laboratory study was adapted from the original experiments covering this phase of knowledge. It was the opinion of the biologists writing this study that the experiments were valid and confirmed the hypotheses that were being tested. The information for this study was obtained directly from the subjects by simply asking them, "Do you consider that the series of experiments in this laboratory study are sound and valid and can be used to answer the above questions? Why?" The answers were judged by two biologists and complete agreement was necessary for acceptance. The following information was obtained and tabulated in Table VII.

TABLE VII

COMPARISON OF RIGID AND NON-RIGID GROUPS AS TO VALIDITY OF LABORATORY STUDY EXPERIMENTS

N Rigid 68 N Non-Rigid 68

	Answered "Valid"	Neutral	Answered "Not Valid"	Total
Non-Rigid	48	11	9	68
Rigid	38	16	14	68
X^2	3.1626	1.1550	1.3080	
Significance level	10%	30%	30%	

It can be seen that forty-eight of the non-rigid group and thirty-eight of the rigid group of sixty-eight individuals in each group, agreed that the experiments were sound and valid. The significance level of this difference was above 10%. Eleven of the non-rigid and sixteen of the rigid category remained neutral in their answers—giving neither a distintcly affirmative nor a distintcly negative answer to the question. Of those categorized as non-rigid, nine gave a negative answer, as did fourteen of the rigid group. The significance of the difference here was above 30%. The chi-square of the total table is 3.175 with two degrees of freedom for a significance level of close to 20%.

The element of causal relationships can also be studied here. The question on Figure 2, "What is the relationship of light to growth in the higher green plants?" can get at this factor. The working of the series of experiments contained in the laboratory study leads to the cause and effect relationship among the factors of light, growth, and bending in plants. Tables VIII and XI presents the data gathered in this phase of the report. A perusal of Table VIII shows that twenty-two rigid and thirty-one non-rigid, each out of a group sixty-eight subjects, were able to see causal relationships existing between the factors of light, growth, and bending. The chi-square of this difference was 2.502 and was significant at the 20% level. On the basis of the type of cognitive structure it

TABLE VIII

COMPARISON OF RIGID AND NON-RIGID GROUPS RELATIVE TO CAUSAL RELATIONSHIPS

N Rigid 68 N Non-Rigid 68

	Rigid	Non-Rigid	X^2	Significance Level
Recognition of Causal Relationships	22	31	2.502	20%
Non-Recognition of Causal Relationships	46	37		

was seen, as shown in Table IX, that the chi-square of the observed difference was 3.574 with two degrees of freedom for a significance level of 20%. On the groupings based on cognitive structure, Table IX, analysis indicates that the significance level, as stated, was 20% which, on the basis of the standard set for this report, is a trend in the hypothesized direction.

TABLE IX

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW COGNITIVE GROUPS RELATIVE TO CAUSAL RELATIONSHIPS

N Comprehensive 46 N Isolated 47 N Narrow 43

	Comprehensive	Isolated	Narrow	X^2	Significance Level
Recognition of Causal Relationships	23	16	14	3.574	20%
Non-Recognition of Causal Relationships	23	31	29		

Arriving at an answer to a problem through a valid experiment does not guarantee that this new bit of information will have any meaning to the investigator as far as ridding himself of a preconceived notion. For instance, many of the students have the preconceived teleological idea that plants bend towards light because the plant needs light and will therefore exert itself to get to the light. Regardless of how the idea arose, the important question here is whether experimental evidence will overthrow a preconceived idea. It is well within the definition of rigidity to postulate that the non-rigid individual will be more receptive, more open to evidence, will be less hesitant in utilizing evidence to the contrary to a long held idea. By comparing the responses to the question, "Why do plants bend towards light?", answered before and after the working of the laboratory exercise, of students who *successfully* (according to the discernment of the judges) completed the exercise, it is possible to see how many subjects changed their ideas on this question when the evidence was available through their own efforts. Using the criterion of rigidity it was found, as shown in Table X, that fifteen of the thirty-two rigid and twenty-six of the forty-one non-rigid, who completed the exercise correctly according to the discernment of the judges, accepted the experimental evidence and modified their ideas to fit the new facts. The chi-square of this difference was found to be 2.0007 with one degree of freedom giving a significance level of above 20%. This indicates a trend towards a suitable level necessary for the rejection of the null hypothesis. With the separation of the subjects on the basis of comprehensive and non-comprehensive thought patterns, no significant differences were obtained.

TABLE X

COMPARISON OF RIGID AND NON-RIGID GROUPS SUCCESSFULLY COMPLETING LABORATORY STUDY ON ACCEPTANCE OF EXPERIMENTAL EVIDENCE AND MODIFICATION OF IDEAS

N Rigid 32 N Non-Rigid 41

	Acceptance of Evidence	Non-Acceptance
Rigid	15	17
Non-Rigid	26	15
X^2	2.0007	
Significance Level	20%	

It was hypothesized that the value of comprehensive is operative in the classroom situation. It has been indicated that upon the testing of this hypothesis on the basis of the elements of the scientific method no clear cut significant differences between subjects with comprehensive or non-comprehensive cognitive patterns were shown. However, this hypothesis can be tested upon another basis. It is assumed that those subjects who are more compre-

hensive in their mental organization are better able to organize the factual information derived from this series of experiments in the laboratory study, and therefore have a greater success in arriving at a correct solution of the problem at hand. Successful completion of the laboratory study was determined by the judges as meaning that the subjects were able to answer all of the questions on Figure 2, showing that they had been able to complete the exercise and understanding the various relationships of light, growth, and bending in the plant. The students finishing the laboratory exercise successfully were assumed to have been able to integrate the materials and evidence of the problem into a comprehensive whole, and therefore to arrive at an acceptable conclusion. The subjects were categorized on the basis of their cognitive organization pattern into comprehensive, isolated, and narrow groups. Table XI gives the data of the analysis. In comparing the comprehensive with the isolated group, it is seen that there were thirty-two successful and correct completions of the study for the comprehensive group as compared with twenty-four for the isolated group. The chi-square of this difference is 3.2966 with significance at the 10% level. This indicates a trend towards rejection of the null hypothesis. Upon comparison of the isolated and narrow groups no significant difference is found for the significance is at the 30% level. It is upon viewing the comprehensive and narrow groups in relation of one another that a high level of significance is found, at above the 1% level. Taking all three groups in relation to each other, the chi-square, with two degrees of freedom, is 8.2587, which is significant at the 2% level. This means for the table as a whole there is a rejection of the null hypothesis, and on the basis of this data the hypothesis may be considered to have been confirmed. It may be noticed

TABLE XI

COMPARISON OF THOSE CATEGORIZED AS COMPREHENSIVE, ISOLATED AND NARROW WITH ABILITY TO SOLVE LABORATORY PROBLEMS

N Comprehensive 46 N Isolated 47 N Narrow 43

	Correct Completion	Incorrect Completion	X^2	Significance Level
Comprehensive	32	14		
Isolated	24	23	3.2966	10%
Isolated	24	23		
Narrow	17	26	1.2595	30%
Comprehensive	32	14		
Narrow	17	26	8.1037	1%

that the trend is from a greater number of correct and complete solutions from the comprehensive group down to the isolated group and from there to the narrow group. It appears to be in the form of a continuum with complete comprehension at one end and complete narrowness at the other end.

The analysis of the data concerning the experiments testing the hypothesis, "The rigid personality structure and the comprehensive cognitive pattern will be found operative in a normal classroom situation which requires the use of the elements of the scientific method for the solution of a problem", suggests that the hypothesis was confirmed. The results, taken as a whole, seem to indicate relationship between nonrigidity and comprehensiveness.

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THE CONSTRUCTION AND VALIDATION OF A TEST TO MEASURE SOME OF THE INDUCTIVE ASPECTS OF SCIENTIFIC THINKING *

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THE purpose of this study was to devise a valid test to measure some of the inductive aspects of the ability to think scientifically. The items of the test were chosen from biological areas because the test was specifically devised for a course in first year biological science at the college level. Educational objectives were formulated and these were defined in terms of the behaviors attending the objectives. Situations were identified in which the students could be expected to display these behaviors and items were written to appraise them. The educational objectives and behaviors attending them have been discussed in a previous article.[1]

A total of 637 tryout test items were written and given to five experts for keying, criticism, and suggestion. The items were revised on the basis of these judgments and assembled into tryout tests. The first tryout test, Test A, was designed to evaluate the student's ability to recognize problems, hypotheses, experimental conditions, and conclusions. Five paragraphs on five different subjects were written. Certain parts of the paragraphs were underlined; these underlined portions, preceded by a number indicating the item number, constituted the 74 items of the test. The directions given to the student, the key for the test and a portion of one of the paragraphs follow:

TEST A

SOME STEPS IN SCIENTIFIC THINKING

This test is designed to measure your ability to differentiate phases of thinking. These steps include major problems or perplexities, possible solutions to problems, observations which are not results of experimentation but rather preliminary observations, results of experimentation, and conclusions.

Certain parts of the paragraph are underlined, and each underlined item is a question. Choose the proper response from the key and blacken the appropriate space on the answer sheet.

* Contribution No. 55 from the Department of Biological Science, Michigan State College.

Paper presented at the Twenty-fifth Annual Meeting of The National Association for Research in Science Teaching, Congress Hotel, Chicago, Illinois, February 16, 1952.

[1] Burmester, Mary Alice. Behavior Involved in the Critical Aspects of Scientific Thinking. *Science Education* 36:259–263, December, 1952.

Key

1. A major problem (either stated or implied).
2. Hypothesis (possible solution to problem).
3. Results of experimentation.
4. Observations (not experimental).
5. Conclusion (probable solution to problem).

Ever since the days of Hippocrates one of medicine's big mysteries has been (1) the bodily process that transforms disease into death. With a special type of equipment which makes blood vessels transparent and three dimensional under a microscope, one investigator began examining the blood of healthy animals. The (2) blood cells of the healthy animals are separate and move rapidly. One day while observing the blood of a monkey dying of malaria, this researcher saw that the (3) blood was flowing slowly.

Test B was designed to test the student's ability to delimit problems. Four major problems were presented; each of which was followed by a series of questions. There was a total of 67 such questions in this tryout test. A portion of Test B follows:

TEST B

THE DELIMITATION OF PROBLEMS

This portion of the test is designed to test your aiblity to delimit a problem. A problem is presented. This is followed by a series of questions. Rate the questions according to the following key.

Key

1. This question must be answered in order to solve the problem.
2. This question if answered *might* be useful in the solution of the problem.
3. The answer to this question, though related to the problem, would not help in the solution of the problem.
4. This question is completely unrelated to the problem.
5. This question if answered in the affirmative is a basic assumption of the problem.

PROBLEM: What causes colds?

QUESTIONS:

1. Do all people have colds?

Test C was designed to measure the student's understanding of the experimental method. A problem and hypotheses were presented.

These were followed by experiments, some of which were satisfactory experiments, others were faulty for one reason or another. Six series of experiments with a total of 62 items constituted Test C, a portion of which is presented here:

TEST C

EXPERIMENTAL PROCEDURES

This test is designed to measure your ability to recognize faulty experimental procedures and to test your ability to select the best of a series of experiments. In each case a problem and a possible solution to the problem (an hypothesis) are presented. In each case the experiments were designed by students to test the hypotheses. Judge each experiment according to the following key.

Key

1. This experiment is satisfactory.
2. This experiment is unsatisfactory because it lacks a control or comparison.
3. This experiment is unsatisfactory because the control or comparison is faulty.
4. This experiment is unsatisfactory because it is unrelated to the hypothesis.
5. None of the above—the experiment or situation is unsatisfactory for reasons other than those listed in 2, 3, and 4.

PROBLEM: What are some of the requirements for the sprouting of seeds?
HYPOTHESIS: Oxygen is a requirement for the sprouting of seeds.

1. Plant one seed in a container where oxygen is available and place another seed in a container where all oxygen has been removed. Keep all other conditions the same.

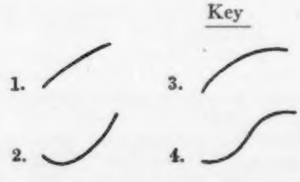
Test D, designed to measure the student's ability to organize data contained twenty items similar to the one illustrated here:

TEST D

ORGANIZATION OF DATA

This test is designed to test your ability to organize data. Select from the key below the curve which best fits the data. If none of the curves fit the data mark space five on your answer sheet.

Key



5. none of the curves.

1. The horizontal axis represents temperature. The vertical axis represents the amount of Substance A derived from Substance B.

Temperature	Amount of Substance A
10° C.	4 grams
25° C.	7 grams
35° C.	9 grams
60° C.	14 grams

Test E is similar to one described by Engelhart and Lewis.[2] It was designed to measure the student's understanding of the relation of facts to the solution of a problem. All of the 74 items of this test were related to the overall problem: What factors are involved in the transmission and development of Infantile Paralysis (Poliomyelitis)? Six hypotheses were presented. Each hypothesis was followed by a series of facts which constituted the items. The data for the test were obtained from articles on infantile paralysis in research journals and medical journals. A portion of Test E follows:

TEST E

Evaluation of Hypotheses

This test is designed to measure your understanding of the relation of facts to the solution of a problem. The overall problem involved in this test is presented. This is followed by a series of possible solutions to the problem (hypotheses). After each hypothesis there are a number of items, all of which are true statements of fact. Determine how the statement is related to the hypothesis and mark each statement according to the key which follows the hypothesis.

GENERAL PROBLEM: What factors are involved in the transmission and development of Infantile Paralysis (Poliomyelitis)?

HYPOTHESIS I: In man the disease is contracted by direct contact with persons having the disease.

Key

For items 1 through 11 mark space:

1. If the item offers direct evidence in support of the hypothesis.
2. If the item offers indirect evidence in support of the hypothesis.
3. If the item offers evidence which has no bearing on the hypothesis.
4. If the item offers indirect evidence against the hypothesis.
5. If the item offers direct evidence against the hypothesis.

1. Monkeys free from the disease almost never catch infantile paralysis from infected monkeys.
2. Most strains of infantile paralysis virus can be transferred from man only to monkeys and apes and not to other animals.

12. What is the status of hypothesis I?
   1. Is it true.
   2. It is probably true.
   3. It is false.
   4. It is probably false.
   5. The data are contradictory, hence its truth or falsity cannot be judged.

Test F was designed to measure the student's ability to interpret data and to test his understanding of experimentation. The directions for this tryout test and a portion of the test are given below:

TEST F

Experimentation and the Interpretation of Data

This test was designed to measure your ability to interpret data and to test your understanding of experimentation. In each case the numbers in the first column are the numbers which you will use as your answer. Thus the table presented becomes both the source of data and your key for the questions which follow it. In each case where a test tube number or group number is called for the one which gives positive evidence for the statement should be given. Below this the control or comparison is called for. This is the test tube or group number of the data which offers a comparison. For example:

1. Leaf in dark—no starch.
2. Leaf in light—starch.

Light is necessary for the production of starch. You would mark space 2 because this is the positive evidence, but it would be meaningless if it were not compared with the leaf in the dark. Therefore, the following item, "What is the control (comparison) for item I?", would be marked space I.

Items I through 15 refer to the data presented below. Some test tubes were set up and each contained 1 gram of fat. They were marked 1, 2, 3, 4, and 5. Mark each item according to the test tube number called for. Various substances were added to the tubes containing fat. All sub-

[2] Max D. Engelhart and Hugh B. Lewis, "An Attempt to Measure Scientific Thinking." *Educational and Psychological Measurement*, 1:289–294, Third quarter, 1941.

stances were dissolved in water before they were added to the fat. All test tubes were kept at 85° F. (Water boils at 212° F.) For test tube 5, Substance A was boiled and then allowed to cool before it was added to the fat.

Test Tube Number	Content of tube	Amt. of Substance B present after 24 hours
1	Fat plus Substance A	.1 gram
2	Fat plus Substance A plus Substance C	.5 gram
3	Fat plus Water	.0 gram
4	Fat plus Substance C	.0 gram
5	Fat plus Substance A (boiled)	.0 gram

1. Give the number of the test tube which acts as a control (comparison) for the entire experiment.
2. Give the number of the tube which gives evidence that fat does not break down spontaneously into Substance B in 24 hours.
3. Give the number of tube used to show that a temperature of 85° F. was not sufficient to cause fat to be broken down into Substance B.
4. Give the test tube number of the tube which gives evidence that Substance A is the active substance in the breakdown of fat to Substance B.
5. Give the test tube number of the tube which is the control (comparison) for item # 4.

Five such series of items were included in Test F. The total number of items was 72.

Test G is somewhat like the test described by Teichman[3] which was constructed to evaluate conclusions in terms of reasonableness, sufficiency and pertinent data. Directions for this test and a portion of the test are presented here.

TEST G

Drawing of Conclusions

This test was designed to measure your ability to make conclusions. When facts are analyzed and studied they sometimes yield evidence which helps in the solution of a problem. However, any conclusion must be checked before it can be accepted. The following key includes four ways in which conclusions may be faulty. Each of the items present a question or problem, a brief description of an experiment and one or more conclusions drawn from the experiment. Each experiment was repeated many times. Read each problem, experiment and conclusions. Where several conclusions are given evaluate each conclusion separately. Is the conclusion tentatively justified by the data? If so, mark space 1 on your answer sheet. If the conclusion is not justified determine whether 2, 3, 4, or 5 in the key is the best reason for it being faulty and mark the proper space on your answer sheet.

Key

The conclusion is:
1. Tentatively *justified.*
2. Unjustified because *it does not answer the problem.*
3. Unjustified because *the experiment lacks a control* (comparison).
4. Unjustified because *the data are faulty or inadequate,* though a control was included.
5. Unjustified because *it is contradicted by the data.*

PROBLEM: A student was interested in developing a test for a certain type of substance. In all 100 cases his test was positive.

1. He concluded that the test was a specific test for the substance.

The final tryout test was in reality two tests, Test H and Test J, combined into one. In all, these tests contained 168 items. Test H was devised to measure the student's ability to interpret data. Data were presented to the students. These were followed by a series of items which were possible interpretations, restatements, explanations, extensions, and comparisons of the data.

TEST H

Interpretation of Data

This test was designed to measure your ability to interpret data. Following the data you will find a number of statements. You are to assume that the data as presented are true. Evaluate

[3] Louis Teichman, "The Ability of Science Students to Make Conclusions." *Science Education* 28:268–279, 1944.

each statement according to the following key and mark the appropriate space on your answer sheet.

Key

1. True: The data alone are sufficient to show that the statement is true.
2. Probably true: The data indicate that the statement is probably true, that it is logical on the basis of the data but the data are not sufficient to say that it is definitely true.
3. Insufficient evidence: There are no data to indicate whether there is any degree of truth or falsity in the statement.
4. Probably false: The data indicate that the statement is probably false, that is, it is not logical on the basis of the data but the data are not sufficient to say that it is definitely false.
5. False: The data alone are sufficient to show that the statement is false.

In freezing of vegetables the common practice for both commercial and home frozen vegetables is to scald the vegetables first by placing them in boiling water for two to three minutes. The following data were obtained in an experiment which measured the amounts of Vitamin C in fresh vegetables, scalded vegetables before freezing, and vegetables frozen for six months. One group of the frozen vegetables was frozen without first scalding, the other group was first scalded. The Vitamin C content of the frozen vegetables was determined before and after they were cooked. All figures indicate the amount of Vitamin C in mg. per 100 cc.

			Frozen			
			Unscalded		Scalded	
Vegetable	Fresh	Scalded	Raw	Cooked	Raw	Cooked
Chard (greens)	60	37	20	2	24	14
Spinach	82	43	10	1	27	16
Peas	29	21	14	10	20	16
Green beans	34	29	25	13	23	17
Lima beans	33	20	26	18	20	14

1. Scalding of all vegetables causes destruction of some of the Vitamin C content of the vegetables.
2. Spinach is a good source of Vitamin C.

TEST J

GENERALIZATIONS AND ASSUMPTIONS

Items 16 through 21 are a re-evaluation of some of the items 1 through 15. Re-read items 1, 3, 9, 11, 13 and 15 and determine whether they are generalizations, extensions of data, explanations of the data or merely restatements of the data, etc. Answer each according to the following key:

Key

1. A generalization; that is the data says it is true for this situation, a generalization says it is true for all similar situations.
2. The data indicates a trend which if continued in either direction would make the statement true.
3. An explanation of the data in terms of cause and effect.
4. A restatement of results.
5. None of the above.

16. Item 1.

This phase of the test is designed to measure your understanding of assumptions underlying conclusions. A conclusion is given. (This conclusion is not necessarily justified by the data). The statements which follow the conclusions are the items which are to be evaluated according to the following key. These items all relate to the data presented for items 1 through 15.

Key

1. An assumption which must be made to make the conclusion valid (true).
2. An assumption which if made would make the conclusion false.
3. An assumption which has no relation to the validity (truth) of the conclusion.
4. Not an assumption; a restatement of fact.
5. Not an assumption; a conclusion.

Conclusion I: The breakdown of Vitamin C proceeds spontaneously but is a relatively slow process at low temperature.

22. Vitamin C is a stable substance.
23. There is order in the universe.

ANALYSIS OF TRYOUT TESTS

The tryout tests were administered to 168 students taking the third term of a three term sequence in Biological Science at Michigan State College in the spring term of 1950. The tests were scored on the basis of total number of items answered correctly. No correction was made for guessing since students were instructed to answer all items.

Item validity of each item of the tryout tests was determined by the method of Davis and of Flannogan. The criterion in each case was the score on the tryout test of which that item was a part. Item difficulties stated in terms of the % of persons answering the item correctly, were estimated by the method proposed by Davis. Means, standard deviations, and reliabilities were calculated for each of the tryout tests. Data on the means, standard deviations, and reliabilities of the tryout tests are summarized in Table I.

TABLE I

COMPARISON OF MEANS, STANDARD DEVIATIONS, AND RELIABILITIES OF THE TRYOUT TESTS

Test	No. of Items	Mean	Standard Deviation	Reliability
A	74	50.60±.62	8.13±.44	.87±.02
B	50	22.46±.37	4.77±.26	.61±.05
C	62	26.30±.41	5.31±.29	.59±.05
D	20	10.94±.32	4.12±.23	.93±.01
E	74	34.37±.49	6.38±.35	.71±.04
F	72	47.85±.66	8.48±.46	.89±.02
G	100	38.01±.92	11.95±.65	.90±.01
H	75	32.19±.49	6.38±.35	.70±.04
J	93	37.37±.71	9.31±.51	.81±.03

Analysis of tryout tests considered as a single test. In all there were 620 items used in the determination of the scores on the total tryout battery. The range of scores was from 183 to 399. The mean for the entire battery of tests was 291.12±3.48, while the standard deviation was 44.22±2.26. The minimum reliability of the test, as estimated by the Kuder-Richardson formula, was .92. ±.01 for this group of students.

The preparation of Test I—The Ability to Think Scientifically. Test I, *The Ability to Think Scientifically,* was constructed from 150 items of the tryout tests. Because of the nature of the items it was necessary to choose blocks of items from the tryout tests rather than individual items. An attempt was made to use items with a discrimination coefficient of .33 or higher.

Ten or 20 items were selected from each of the tryout tests with the exception that only four of the best items were selected from Test D.

ANALYSES OF TEST I AND TEST IA

Test I, *The Ability to Think Scientifically,* was administered to 500 students who had complete a year of Biological Science at the end of the spring term of 1950 and to 240 students who had not yet had Biological Science at the beginning of the fall term of 1950. Test IA, the 125 item final form of the test, *The Ability to Think Scientifically,* was administered to 330 other students who had not yet taken Biological Science at the beginning of the fall term of 1950. Test IA was also administered to 136 of this same group at the end of the first term of the course.

Analysis of Test I, The Ability to Think Scientifically. Test I was comprised of a total of 150 items. The range of scores for the students who had completed the year course was from 30 to 117. The mean of the test for this group was 78.92 ±.73; the standard deviation was 15.41 ±.52. The reliability of the test for this group was .89±.01 as determined by the split-half method corrected by the Spearman-Brown formula. By using the Kuder-Richardson formula a reliability of .85±.01 was obtained.

The range of scores for the students who had had no college biology was from 27 to 107. The mean for this group was 60.64 ±1.18, the standard deviation was 17.32 ±.83. The reliability for this group was .91±.01 calculated by the split-half method corrected by the Spearman-Brown formula. The Kuder-Richardson formula gave a value of .89±.01.

The mean of the test and the mean item difficulty (32 per cent success) gave evidence that the test was probably a little too difficult for the group for which it was devised.

It is of interest to note that the discrimination indices obtained by using Test I as the criterion were, with a few exceptions, lower than the indices obtained by using the individual tryout tests as the criterion. Since each of the tryout tests was constructed to measure a rather narrow range of abilities, individual items would be expected to be more highly correlated with the score of the single tryout test of which they were a part, than with the test on many of the abilities involved in scientific thinking.

Analysis of Test IA—The Ability to Think Scientifically. Since items were presented in blocks centering around a particular problem or experiment, they could not be arranged in order of difficulty. It was not intended that the test be designed as a speed test, and the nature of the sequence of items was not such that it could be arranged as a power test. Since the test was devised to measure growth and was to be used as a means of evaluating instruction, it seemed advisable to make the test of such a length that all, or at least 99 percent, of the students could finish it in the allotted time. Since 10 percent of the students failed to complete Test I in the hour and fifty minutes available, 25 of the poorer items of Test I were eliminated on the basis of item analysis to make Test IA.

Test IA was administered at the beginning of the fall term of 330 students who had had no Biological Science. The range of scores made by this group was from 23 to 101. The mean of Test IA was 53.16 ± 1.11, while the standard deviation was $16.28 \pm .78$. The reliability as determined by the split-half method with the Spearman-Brown correction was $.91 \pm .01$. The Kuder-Richardson formula gave a reliability of $.89 \pm .01$.

This test was administered to 136 of the same students at the end of the fall term of 1950, in other words, after one term of Biological Science. The range of scores for this group was from 31 to 103. The mean was 69.94 ± 1.41, and the standard deviation $16.43 \pm .99$. The reliability as determined by the split-half method corrected by the Spearman-Brown formula was $.90 \pm .02$. The reliability as calculated by the Kuder-Richardson formula was $.89 \pm .02$.

THE STATISTICAL VALIDATION OF THE TEST

Validation by correlation with measures of intelligence, reading ability, and factual information. The first method used to establish the statistical validity of the test was the correlation of scores made by students on the tests with other kinds of tests. In a sense, this is a negative form of validation because a high correlation of this test with measures of such traits as intelligence, reading ability, and knowledge of facts would indicate that the test could not then measure what it purported to measure. It cannot be assumed, however, that the test is a valid measure of ability to think scientifically merely because of a lack of substantial relationship to any of these factors.

Preliminary evidence concerning the statistical validity of the test was obtained by correlating the total scores made by 168 students taking the tryout tests with; (1) the quantitative scores on the American Council on Education psychological examinations, (2) the linguistic scores of the American Council on Education psychological examinations, (3) the total psychological examination scores, (4) total scores on the American Council on Education Reading Test.

American Council on Education psychological examination scores and reading examination scores were available for 264 of the 500 students who took Test I, *The Ability to Think Scientifically,* in May, 1950. The scores made by these 264 stu-

dents on Test I were correlated with; (1) the quantitative scores on the psychological examination, (2) the linguistic scores on the psychological examination, (3) the total scores on the psychological examination, and (4) the total reading test scores. These correlations together with those obtained by correlating the same four factors with the total tryout test scores are given in Table II. The standard errors of the correlations ranged from .04 to .07.

TABLE II

CORRELATION OF TRYOUT TEST SCORES AND SCORES ON TEST I WITH PSYCHOLOGICAL EXAMINATION SCORES AND READING SCORES

Tests	Quantitative	Linguistic	Total Psychological	Reading
Tryout	.45	.38	.51	.49
Test I	.48	.43	.51	.43

Validation by comparison of scores of various groups. Another method of statistical validation of the test was the comparison of scores made by students who had not yet taken Biological Science with scores made by students who had taken Biological Science.

The scores of students at the beginning of the course in Biological Science were compared with the scores made by another group at the end of the three-term course in Biological Science. This comparison involved the assumption that the groups were both representative samples of the same population.

The scores of students at the beginning of the course in Biological Science were also compared with their scores at the end of one term. This method relieves one of making an assumption concerning the nature of the group, but involves the assumption that memory would play no substantial part in any observed increase in scores. However, if the two methods gave substantially the same results valid inferences concerning the validity of the test could probably be drawn. The validation of the test by these comparisons is based on the assumption that increase in scores results from instruction in the objective being tested and not on a maturation factor.

As previously mentioned, Test I was administered to 500 students who had completed three terms of Biological Science. Of this group 446 completed the test. The scores made by this group were compared with the scores made by 216 other students who completed the same test before taking Biological Science. A comparison of the scores of the two groups, as presented in Table III, gives evidence that there was improvement of scores and that this improvement was highly significant. The critical ratio of 13.15 showed that this difference between the two means was not due to chance.

TABLE III

COMPARISON OF MEANS AND STANDARD DEVIATIONS OF TEST I FOR A GROUP BEFORE TAKING BIOLOGICAL SCIENCE WITH ANOTHER GROUP AFTER TAKING THREE TERMS OF BIOLOGICAL SCIENCE

Group	Number	Mean	Standard Deviation	Critical Ratio
3 terms of Biological Science	446	78.92	15.41	13.15
No Biological Science	216	60.64	17.32	

A comparison was also made of the scores made by 136 of the group who took Test IA before taking Biological Science, that is, a pre-test group, and the scores on the same test made by this group after one term of Biological Science, a post-test group. The data for this phase of the study are presented in Table IV. The

TABLE IV

COMPARISON OF MEANS AND STANDARD DEVIATIONS OF A TEST IA ON THE PRE-TEST AND POST-TEST

Group	Number	Mean	Standard Deviation	Critical Ratio
Pre-test	136	55.60	15.84	8.62
Post-test	136	64.94	16.43	

critical ratio of 8.62 gives further evidence that the difference between the two means was not due to chance.

Since in both comparisons the differences between the means were highly significant and both in the same direction we may make the tentative inference that the test had some validity in that there was an increase in score attending instruction in the methods of science.

Validation by comparison of scores with ratings of students by competent judges. The final method used in the statistical validation of the test was the comparison of scores made on the test with the rating of competent judges. A rating scale for the ability to use the scientific method was prepared.

Students were rated by their instructor on; (1) the ability to devise and evaluate experiments, and (2) the ability to interpret data, including the ability to form hypotheses and draw conclusions.

The ratings were on a five point scale; very superior, superior, average, inferior, and very inferior. One hundred and forty-three students taking the first term of Biological Science were given Test IA at the beginning of the first term of the three-term sequence of the course. Test IA was administered again to 136 of these same students at the end of the first term. A part of these students were taught by the present investigator and the remaining students were taught by another instructor. Each of these students was rated by his instructor.

Students taking Biological Science at Michigan State College do not necessarily have the same instructor for more than one term, therefore, during the second term most of these students had a different instructor. These students were scattered throughout the classes of 19 instructors teaching the second term of the three-term sequence. These instructors were requested to rate the students used in this study on their ability to think scientifically. Thus each student was rated by two instructors, but were not all rated by the same instructor.

In order to use these ratings in statistical computation, composite ratings were calculated for each student. A very superior rating was allotted 5 points, a superior rating 4 points, an average rating 3 points, an inferior rating 2 points, and a very inferior rating 1 point. Since each student was rated on two abilities by two judges, a maximum of 20 points and a minimum of 4 points was the range of possible scores on the composite rating.

Because there were very few rated by both raters as either very superior or very inferior, a comparison of means was made on the basis of superior, average, and inferior ratings. Rating scores from 10 through 14 were considered average, scores below 10 were considered inferior, and scores above 14 were considered superior.

These comparisons are presented in Table V.

The differences between the means and the critical ratios of these differences were calculated. Table VI gives evidence that the group rated as superior was superior

TABLE V

MEAN GAINS OF STUDENTS RATED AS SUPERIOR, INFERIOR AND AVERAGE ON TEST IA

	Group					
	Pre-test			Post-test		
Ratings	No.	Mean	Standard Deviation	No.	Mean	Standard Deviation
Superior	22	77.00	10.10	22	92.00	7.07
Average	82	57.10	12.63	81	70.45	12.12
Inferior	38	39.39	8.18	30	55.17	12.15

TABLE VI

DIFFERENCES IN MEANS AND CRITICAL RATIOS OF DIFFERENCES BETWEEN STUDENTS RATED AS SUPERIOR AND AVERAGE AND STUDENTS RATED AS AVERAGE AND INFERIOR

Group	Superior Dif. in mean	Average C.R.	Average Dif. in mean	Inferior C.R.
Pre-test	19.90	10.59	21.55	12.75
Post-test	17.73	10.75	15.28	8.08

on performance on the test to a highly significant degree and the performance of the group rated as inferior was poorer than the performance of the group rated as average to a highly significant degree.

Table VI is also of interest in that it gives evidence that the increase in scores was not restricted to any particular group; the means of all of the groups, superior, average, and inferior being higher after a term of Biological Science.

The final method used to indicate the validity of the test was the determination of validity coefficients. Coefficients of correlation were calculated between total scores on the rating scale and (1) scores made on the test prior to taking Biological Science and, (2) scores made on the same test after one term of Biological Science. These correlations were $.77 \pm .04$ and $.72 \pm .04$ respectively. Such correlations give evidence that the test had a considerable degree of validity providing the ratings of the judges were valid.

BOOK REVIEWS

CONNOR, WILLIAM H., CROSS, BURNETT, EVANS, HUBERT, AND TANNENBAUM, HAROLD. *Electric Power and Social Policy.* New York: Bureau of Publications, Teachers College, Columbia University, 1951. 53 p. $.75.

This is a resource guide for teachers and discussion leaders. It was the result of a workshop on electric power, one of a series of technology workshops conducted by Teachers College, Columbia University, principally for teachers of natural and social sciences. Twenty-five teachers from many sections of the country, brought together on scholarships, participated in the workshop. The production of material for a resource guide was a major goal of the workshop.

There are five units as follows:

1. Electric Power and Education, 2. The Widespread Use of Electric Power and Its Social Impact, 3. The Technical Base of Electric Power, 4. Electric Power—A Strategic Industry, 5. American Technology and Social Policy—Major Issues.

Numerous charts and photographs supplement the content.

SYMPOSIUM. *Resource Guide for General Biological Science.* Atlanta, Georgia:, Board of Education, City Hall, 1951.

This is a course of study in biology for the Community High Schools of Atlanta, Georgia. There are four sections to the course of study, each section containing two units. The eight units are as follows: 1. What Are the Differences Between Living and Non-Living Things?, 2. How Are Plants and Animals Sorted into Groups?, 3. What Is Food?, 4. How Are Foods Used?, 5. Why Do Living Things Behave as They Do?, 6. How Does Life Continue?, 7. Why Are Living Things Like Their Relatives?, and 8. How Does Biology Improve and Enrich Our Lives?

Each unit is divided into a series of subproblems. The unit is primarily organized into two parallel columns one devoted to *Suggested Teacher Activities* and the other *Anticipated Pupil Outcomes.*

Each unit has a list of projects and a list of references.

This course of study is an excellent resource guide for all teachers of biology regardless of the textbook used or the community in which the biology is being taught. It is quite comprehensive containing more material than any teacher is expected to use.

Dr. Kenneth R. Williams and Mrs. M. Gordon Brown of the Atlanta Public Schools served as coordinators in the study. Dr. Philip Johnson of the U. S. Office of Education and Dr. W. B. Baker of Emory University served as consultants. The following Atlanta High School teachers served as the Curriculum Committee for General Biology: E. P. Ellington (Grady High School), W. H. Holcomb (O'Keefe High School), C. J. Lammers (Murphy High School), Susan F. Leonard (Bass High School), Martha L. Mills (Sylvan Hills High School), Cleo E. Sampson (Roosevelt High School), T. H. Walton (Brown High School), and Katherine M. Hertzka (Smith High School).

ALTER, DINSMORE AND CLEMINSHAW, CLARENCE H. *Pictorial Astronomy*, New York: Thomas Y. Crowell Company, 1952. 296 p. $4.50.

Pictorial Astronomy is one of the finest books in astronomy intended for the layman appearing in quite a long while. It could be used as a textbook in high school or for a cultural short course in college. However it is not a textbook in the usual sense of the term. There are an unusual number of excellent, pertinent illustrations. A number of tables of interesting data so often asked for by laymen are included.

Nearly every phase of astronomy interesting to the layman has been included. There are sections dealing with the sun, earth, moon, eclipses, planets, comets and meteors, stars and nebulae. One section entitled "Miscellaneous" discusses the nature of radiation, some famous telescopes, and life in the universe.

Being up-to-date as it is, the reviewer considers *Pictorial Astronomy* as the finest book in popular astronomy now available to the layman. It is especially recommended as an excellent reference for teachers of elementary science and genral science in the junior high school. Science has no area that is more challenging or interesting to read about than astronomy. *Pictorial Astronomy* is designed for that very purpose.

Experiments with Water; Experiments with Air; Experiences with Fuels and Fires; Experiences with Heat; Experiences with Magnetism and Electricity; Experiences with Sound; Experiences with Light and Color. Washington, D. C., 1201 Sixteenth Street N. W.: The National Science Teachers Association, 1950, 1951. 44 p., 30 p., 39 p., 72 p., 44 p., 46 p. $4.00 for seven volumes.

This series of seven volumes is based upon more than ten years of development. The books are designed for elementary and junior high school science teachers. Most of the decriptive material has to do with suitable experiments and experiences in the respective areas of the physical sciences. Numerous sketches and diagrams add to the clarity and understanding of the experiments described. Each of the volumes is divided into a number of parts with many experiments described under each part. There are 27 experiments on air; 26 on fuels and fire; 31 on heat; 49 on magnetism and electricity; 25 on sound; and 27 on light and color. Most of the experiments can be readily performed by children with relatively inexpensive equipment and materials.

Elementary and general science teachers can, with the exception of a few quite experienced teachers, greatly improve the effectiveness of their science teaching by having on hand and using the many experiments described. Professor Bruce of the New Jersey State Teachers College at Newark, New Jersey is to be much commended for preparing and making available such a useful compilation of physical science experiments and experiences. The National Science Teachers Association is performing a very valuable service to science teachers everywhere in making these volumes available at a relatively nominal cost. The volumes would serve excellently as references in any elementary or secondary science classroom.

SCIENCE COMMITTEE OF THE NEW JERSEY LIBRARY ASSOCIATION. *Meet the Sciences.* Newark, New Jersey (34 Commerce Street): New Jersey Library Association Committee, 1951. 6 p. $0.10.

This is a briefly annotated science book list. Fifty more recent publications are listed. General readers and science teachers will be especially interested in the bibliography.

ANONYMOUS. *A Manual for Student Teaching.* Oswego, New York: The Division of Elementary Education, The State Teacher's College. 10 p.

This pamphlet presents the Oswego Plan of Pre-Student-Teaching Experiences, Suggestions for the Cooperation Centers, and Instructions to Student Teachers. The latter includes: student teaching, a privilege and a responsibility; living in the community; desirable personality traits; preparing to go student teaching; the student teacher in the community, in the cooperating school, and in the assigned classroom; the student teacher's notebook; the student teacher's weekly reports; and the evaluation of progress in student teaching.

Both prospective student teachers as well as those in charge of directing student teaching will find this a most valuable pamphlet.

FERGUSON, RUBY, BOLAND, JAMES, AND LINTON, ALMA. *Atomic Understanding.* San Jose, California (408 Almaden): Department of Instruction, San Jose Unified School District, 1951. 78 p.

Atomic Understanding is a guidebook for teachers and students of secondary schools. It was produced under the general direction of the Civil Defense Committee of the San Jose Unified School District. It is in response to realization of the school's responsibility and the school's business in civil defense. The need is imperative for teachers and students to become informed about the basic facts of atomic energy.

The guidebook presents guide lines and goals for student study, illustrations and tables, suggested activities, evaluation, glossary of atomic terms, and references. The list of references is unusually well selected, complete, and classified. Books, magazine articles, and pamphlets are included.

Altogether this is the finest atomic energy

guidebook or course of study produced by any city or state curriculum committee. The San Jose committee is to be highly commended for such an important contribution in what this reviewer considers a most critical and needed area. There is much evidence that American public education and the American public at large is taking a dangerous, nonchalant attitude toward civil defense against the atomic bomb. Every school in America is in need of carrying out a program of atomic civil defense study as seems to be the case with the San Jose School District. In this production they have made an outstanding contribution that should serve as challenge to American secondary schools everywhere.

HORKHEIMER, MARY FOLEY AND DIFFOR, JOHN W. *Educators Guide to Free Films.* Randolph, Wisconsin: Educators Progress Service, 1952. 508 p. $6.00.

This is the twelfth annual edition of this unusually fine guide. It is a complete, up-to-date, annotated listing of free films, 538 of which were not listed in the previous edition. All new titles are starred.

Science teachers should especially appreciate the *Educators Guide to Free Films.* There are 40 films listed in biology of which 6 are new; 106 in chemistry of which 9 are new; 163 in general science of which 29 are new; 96 in physics of which 11 are new; 91 in conservation of which 10 are new. In addition films listed under aeronautics (233 with 18 new), agriculture and soil conservation, nutrition and diet, and consumer education may be of equal value and interest to science teachers.

Altogether this is the best most comprehensive listing of films available. Many science teachers use this listing but there are many more that should be doing so.

HORKHEIMER, MARY F. AND DIFFOR, JOHN W. *Educators Guide to Free Slide Films.* Randolph, Wisconsin: Educators Progress Service, 1952. 172 p. $4.00.

This is the fourth annual edition of *Educators Guide to Free Slide Films.* In 1946, only 82 free slidefilms were available from 40 sources. This edition lists 575 titles, including 153 new titles. This indicates a rapidly growing trend in a relatively new visual aid. Quality has improved very much in this period, too. Teachers will find the discussion on *How to Use Slidefilms and Your Slidefilm Guide* very useful. Many science slidefilms are listed, making it especially helpful to science teachers.

LANSDOWN, BRENDA. *Workbook on Scientific Thinking.* New York (108 East 89th Street): The Dalton Book Shop, 1950. 68 p. $1.00.

This is Book I of a proposed series of workbooks on scientific thinking, emphasizing the general theme, *The Chemical Background of the Atom.* The workbook was devised to be used in a physical science course taken by all Eleventh Graders in the Dalton High School.

The author says in the foreword to the student, "This is a teaching-workbook on scientific thinking. It aims to teach you something about how thought operates in the world of science and then to give you exercises in thinking for yourself—we mean just that—thinking for yourself. There may be more than one possible answer to many of the questions."

The workbook gives facts upon which the questions are based. No answers are given. The author believes that the workbook properly used should go a long way toward giving the student practice in scientific thinking and to bridge the gap between thinking in science, and applying scientific thinking to everyday life. Definitely this is a step in the right direction and much more effort should be directed toward providing more similar material for classroom use. Then possibly we would make more significant gains toward the problem of developing adequate problem-solving techniques and scientific thinking. Science teachers who are interested at all in teaching something about the scientific method will be very interested in examining this workbook and perchance in trying it out in their own science classes.

Although some illustrations are not from science, most of them are, and students will learn much new science, presented to them in a challenging, unique way.

MARSHALL, ROY K. *The Nature of Things.* New York: Henry Holt and Company, 1951. 188 p. $2.95.

The Nature of Things is one of the finest popularizations in this area of science that has been published. Written in a most interesting and readable literary style, the content is at the same time quite accurate—as accurate as it is possible to be when science is reduced to simple and non-mathematical terms. Illustrations by Jon Gnagy add much to the charm and understanding of the book.

Dr. Marshall for some four years has been televising a program called "The Nature of Things" over Philadelphia station WPTZ. Readers of popular science material, elementary and secondary teachers will find the books quite suitable to their needs and understanding.

A few of the twenty-three chapters include: the inside of atoms, discontented atoms, the atomic bomb, the heart of a star, man-made rainbows, motions of the stars, the wandering stars, measure of the stars, and the expanding universe.

This is a highly recommended book for the high school science library.

LEWIN, PHILIP. *Arthritis and the Rheumatic Diseases.* New York: McGraw-Hill Book Company, 1951. 175 p. $3.50.

Written for laymen, this book offers help and hope for over seven million Americans now suffering from arthritis and the rheumatic diseases. The author believes that scientific research now under way may well result in complete cure within our lifetime. The new "wonder drugs" cortisone and ACTH have brought unparalleled relief to many arthritic sufferers but their long-time benefits are yet to be determined. They do not represent the miraculous cure that has so long been sought.

The author presents a most readable account and description of the arthritic diseases with comments as to what the sufferer may himself do to lessen its effects and aid the individual in complete recovery in numerous instances.

HYLANDER, C. J. *Adventures With Reptiles: The Story of Ross Allen.* New York: Julian Messner, Inc., 1951. 174 p. $2.75.

This is primarily the story of Ross Allen, a herpetologist who owns and operates the Reptile Institute in Silver Springs, Florida. Ross Allen is a self-educated naturalist who turned a hobby into a life's work—a hobby that started with snakes and developed into a special interest in crocodiles and alligators. Today he is an outstanding authority on reptiles. He has saved hundreds of lives through his venom laboratory which supplies the materials out of which antivenom is produced and which protects the victims of snake bites from its deadly results.

The Reptile Institute is a family affair, his wife and young sons being as much at home with snakes and frogs as most persons are with cats and dogs. At the Institute not only is venom extracted and prepared for use, but rattlesnake fillets are canned and shipped all over the world, and the skins prepared for leather. Many of his adventures have been recorded for movie shorts.

Ross has spent 25 years on exploring trips to Central and South America, Cuba, the Everglades and Okefenokee Swamps. Probably no other person knows the Everglades and Okefenokee Swamps as well as does Allen.

Altogether, this is an unusually interesting story written by one of America's better science writers. Many readers of *Science Education* will remember with delight his earlier books, *World of Plant Life, Out of Door* series (four volumes), *The Year Round, Seas and Shore,* and *American Inventors and American Scientists.* It is recommended as an excellent book for all nature lovers and for high school biology teachers and students.

HAMILTON, CHARLES. *Cry of the Thunderbird: The American Indian's Own Story.* New York: The Macmillan Company, 1951. 283 p. $4.00.

Cry of the Thunderbird is the Indian's story of his American History. More than fifty authors and half as many tribes are represented in this collection of Indian accounts and literature. The source material quoted is very rare and nearly all of it reappears for the first time since original publication, some of the most significant being so scarce as not to be found in even the largest libraries and museums. The Indian's account of the American Revolution, the War of 1812, frontier wars and early colonial adventures into Indian territories present an entirely new viewpoint in the American settler's and government's moves westward. Black Hawk tells the inside story of the war that bears his name; Chief Joesph about his famous 1200 mile retreat which many military experts now regard as one of the most skillfully executed retreats in history; then there is Pontiac, Tecumseh, Sitting Bull, Geronimo, and many others.

This book is a *different American History* book. The reviewer enjoyed the numerous incidents and stories told by some of the original Americans.

BLEEKER, SONIA. *The Apache Indians.* New York: William Morrow and Company, 1951. 157 p. $2.00.

The Apache Indians are known as the raiders of the southwest and among the most colorful of all Indian tribes. Fierce raiders and fighters, they were for hundreds of years the terror of more peaceful tribes and frontier settlers of Arizona, New Mexico, Texas, and Northern Mexico. They were wanderers. The women were skillful potters and basket makers. The daily lives, history, crafts, work is interestingly told by Sonia Bleeker, an anthropologist and authority on North American Indians.

BLEEKER, SONIA. *The Sea Hunters.* New York: William Morrow and Company, 1951. 159 p. $2.00

The Sea Hunters is the third book in the author's important series on North American Indian tribes. *Indians of the Longhouse,* the story of the Iroquois, and *The Apache Indians* have been reviewed in *Science Education.* Unlike the Iroquois who were farmers, the sea hunters were skillful fishermen and sea hunters. Except for a few berries and roots, their entire diet consisted of sea foods. These Indians lived along the northwest coast from northern Oregon to Alaska.

Salmon, sea otter, porpoise, whale, halibut, and herring constituted their existence—their vocation, food, clothing, social life.

The author details the daily life and activities of these sea-hunting Indians as they must have lived and enjoyed it. The author is an anthropologist who has devoted years to the study of North American Indians. The description and details of the story are thought to be as accurate as is possible to describe them. The author brings the story up to date from a period long before the white man came to this area until the present status of these Indians today.

Altogether the series by Sonia Bleeker constitute an outstanding contribution to a better understanding of the first Americans. As previously said in another review, the daily, peacetime activities of these early Americans are stressed. Undoubtedly it is a far more accurate description than the earlier and more usual war-like descriptions so many people remember.

BALCH, GLENN. *Indian Fur.* New York: Thomas Y. Crowell Company, 1951. $2.75.

This is the story of life as a fur trapper in the western Rocky Mountains in the early 1800's. John Daniels sets out to trap furs and find his brother who had gone west some years previously. Living with a fur-trapper, Arny Bliss, young John Daniels makes friends and lives with Kuna and Nompa, young Indian boys of the Shoshones!

Young boys of teen age will enjoy this story of beaver-trapping and Indian life as depicted in early American history.

BURT, OLIVE. *Jerediah Smith.* New York: Julian Messner, Inc., 1951. 187 p. $2.75.

This is the story of Jerediah Smith, a fur trapper of the old west. Smith was one of a number of fearless men who braved the western wilderness to establish the fur trade which in turn led to a much earlier colonization of the West. When Diah joined the Rocky Mountain Fur Company in 1822, St. Louis was the fur capital of the new world. Hostile Indians, loss of supplies, stolen pelts, hunger, thirst, extreme heat and cold were all a part of the adventures of Diah who brought to a most successful close his career as one of America's foremost fur hunters. Ironically enough he was killed by Comanche Indians in the dreaded Jornada del Muerte desert between the Arkansas and Cimarron Rivers, on a trip over the Santa Fe Trail to the Southwest, the purpose of which was to trade for Mexican silver.

Altogether this is a most interesting story of adventure and life in the early West, a story based on historical material and incidents.

GENDRON, VAL. *The Fork in the Trail.* New York: Longmans, Green and Company, 1952. 208 p. $2.75.

This is the story of Wint Hanners who started for the fabulous gold fields of California in a rickety farm wagon, all a part of a wagon train. Dropping out when his wagon broke down, Wint drops out and under the friendly protection of the powerful Sioux Indians builds up a fine herd of cattle, intending to proceed to California a little later. But a stranded family from Kentucky necessitates a change in plans and Wint eventually decides on cattle raising on the Texas plains. Delightfully written in a most intesting literary style, both juvenile girls and boys will enjoy this story.

WYATT, GERALDINE. *Sun Eagle.* New York: Longmans, Green and Company, 1952. 172 p. $2.50.

This is the story of Brit Mason, one-time captive of the Comanche Indians, and Jesse Chisholm and their trading trek through mountains and deserts, to California in the year 1839. Boys will enjoy this tale of early adventure among the Indians of the southwest.

ADRIAN, MARY. *Garden Spider.* New York: Holiday House, 1951. 38 p. $2.00.

The Garden Spider, Miranda Aurantia is widely known. It is found in gardens and fields throughout the eastern part of the United States, from New England to the Dakotas and South to the gulf. Garden Spider is by turns hunter, parachutist, engineer. She is a master spinner—not of one, but of three kinds of silk.

These scientific facts are simply told for a young child to read himself. They have been checked for scientific accuracy by John C. Pallister, Research Associate of the American Museum of Natural History. There are delightful illustrations in color by Ralph Ray.

OAKES, VANYA. *Willy Wong, American.* New York: Julian Messner, Inc., 1951. 174 p. $2.50.

Willy Wong of San Francisco's Chinatown wanted to be considered by his fifth grade classmates a 100% American. And he thought the best way to do that was to make the fifth grade baseball team. But he couldn't hit! But he did win fifth grade second place in an all-San Francisco project contest and proved to himself, his relatives, and his classmates he was truly 100% American. This is an excellent book for developing better inter-cultural understanding between different racial groups and nationalities. It is recommended as being a fine addition to the school library.

EAMES, GENEVIEVE TORREY. GHOST TOWN COWBOY. New York: Julian Messner, Inc., 1951. 176 p. $2.50.

This a Junior Literary Guild selection. The book tells the story of an orphan boy Steve who helps his uncle prospect for gold in an old western ghost gold town. Steve all the time

wants to live on a ranch and have a ranch of his own. The discovery of uranium deposits finally helps Steve to realize his dream. The story is well told and will appeal to most boys.

Bronson, Wilfrid S. *Pinto's Journey.* New York: Julian Messner, Inc. 56 p. $2.50.

Children will like to read this story. They will thoroughly enjoy *Pinto's Journey.* Pinto Goodluck is a Pueblo Indian boy living in an adobe home in New Mexico with his mother and grandfather. The grandfather made most of the living, making beautiful jewelry from silver and turquoise. The Great War came and the source of turquoise dwindled to nothing. The grandfather knew a secret mine where, had he been able, he could mine turquoise. Pinto learns about the mine and just before Christmas sets off with his burro Ambrosio to get turquoise for his grandfather. His adventure—this journey—is the basis of the main part of the story. A good deal of science is woven into the story. Mr. Bronson is a well-known writer of science for children.

MacGregor, Ellen. *Miss Pickerell Goes to Mars.* New York: Whittlesey House, McGraw-Hill Book Company, 1951. 128 p. $2.25.

This is a science fiction story for boys and girls 8 to 12 years old. Miss Pickerell inadvertently made a history-making flight to Mars. The story of the trip to Mars and what they found there will interest most boys and girls. The author has stayed within the bounds of probability both as to the flight itself and the conditions they found on Mars. In the science fiction field this is a highly recommended book.

Reck, Franklin M. *The American Boy Anthology.* New York: Thomas Y. Crowell Company, 1951. 488 p. $3.00.

The magazine *The American Boy* probably attained a popularity among boys never attained by any other magazine. In many homes its arrival every month was the *Event* of the month, and for once many boys became insensitive to play or meals, or home work chores. It was a magazine edited expressly for older boys. It was a companion publication to the family magazines *Youth's Companion* and *St. Nicholas.* The first issue appeared in November, 1899. Many noted writers contributed stories to *The American Boy*—a number over a period of many years. Among these were William Heyliger, Clarence Budington Kelland, Ralph Henry Barbour, Harold Titus, Glenn Balch, and others. The greatest year for *The American Boy* was 1929 when it took over the failing *Youth's Companion* and for a time had a circulation of 360,000. Largely due to the depression and the resulting accumulated debt *The American Boy* ceased existence in 1941.

The present volume is a selection of some of the well-written fiction that delighted many a boy of an earlier age. The stories are really "tops" as any present-day boy reading them is most likely to agree. Altogether this is a fine collection of boy stories.

A few of the stories and their authors include: *Mack Tidd in the Backwoods* by Clarence Budington Kelland; *"Hoot" Said the Owl* by Ralph Henry Barbour; *Passengers for Panama* by Howard Pease; *A Price on Hide-rack* by Glenn Balch; *Tierney Meets a Millionaire* by John A. Moroso; and *The Mystery of Four-and-a-Half-Street* by Donald and Louise Peattie.

Henry, Will. *Wolf-Eye: The Bad One.* New York: Julian Messner, Inc., 1951. 173 p. $2.50.

This is the story of a German Shepherd dog (Wolf-Eye) whose part-wolf ancestry finally made him a cruel, man-hating, untamable wolf. Jim Lewis on his Arizona ranch developed him into an unusual, shrewd herder of dangerous long-horned cattle. Unable to resist the call of Vega, the she-wolf, Wolf-Eye leaves his owner to live with Vega. In his new environment and new family, Wolf-Eye, Vega and their offspring become the terror of Arizona ranchers. For self-protection, the ranchers have to hunt them down. Wolf-Eye finally pays his debt by saving the life of Jim Lewis at the expense of his own. Boys and girls will thoroughly enjoy this story of a dog, based on many true incidents. Illustrations are by Wilfrid S. Bronson, well-known author of many animal stories.

Bendick, Jeanne. *How Much and How Many.* New York: Whittlesey House, McGraw-Hill Book Company, 1947. 188 p. $2.25.

This is the story of weights and measures. The book explains not only what they are but how they got that way and why. Familiar, everyday weights and measures are given, the many others used in sciences and trades that touch us all the time. It seems that almost everything is weighed, or measured, or counted in someway. It is a most readable book, not merely a dry reference book. There are more than 200 clever pertinent illustrations by the author. It is an excellent book for all science teachers—elementary, junior high, and secondary. It is an excellent reference for the library and the science book shelf.

Bendick, Jeanne. *All Around You.* New York: Whittlesey House, McGraw-Hill Book Company, 1951. 48 p. $2.00.

All Around You is a science picture book that describes with simple words and clever, fascinating illustrations the why and how of the world about us. It is a first look at the world.

The book answers many questions about such things as the sun, moon, stars, clouds, sky, rainbows, shadows, lightning, thunder, rain, fog, wind, air, plants, sleet, ice, water, soil, animals, seeds, and so on. The illustrations by the author are unusually fascinating. It is an excellent book for intermediate grade children and as a reference for elementary science teachers. There is an introduction by Glenn O. Blough.

HUNTINGTON, HARRIET E. *Aircraft, U.S.A.* Garden City, New York: Doubleday and Company, Inc., 1951. 52 p. $2.50.

This is a book of modern military aircraft suitable for any age. The material in the book has been cleared with the Office of Public Information, U. S. Department of Defense.

Each page is illustrated with actual photographs, with brief but comprehensive description of the most important features of each plane. Spotter silhouettes are used in conjunction with the photographs which will be useful to anyone interested in aircraft identication.

Training planes, jet planes, raiders, fighters, interceptors, transports, helicopters are all included. Many boys will be thrilled with such a book. It is an excellent book for the science library.

HOLT, STEPHEN. *The Whistling Stallion.* New York: Longmans, Green and Company, 1951. 211 p. $2.50.

This is the story of a young boy's struggle against the forces of nature, primarily that of weather. The scene is laid in Canada just north of Montana. Roy Bell's father is hospitalized and about to lose the Bell Ranch. Young Bell meets the challenge with the help of a kindly neighbor whose cattle he feeds and cares for through the cold bitter winter and against the attacks of bears and wolves, only to lose a major part of them in a late spring blizzard as they stampede over a cliff. Roy's capture and taming of a wild stallion Whistler is a major theme of the story that most boys and girls will thoroughly enjoy. A boy's love of horses and the out-of-doors is interestingly portrayed.

RUSH, WILLIAM MARSHALL. *Wild Horses of Rainrock.* New York: Longmans, Green and Company, 1951. 236 p. $2.50.

This is primarily the story of Dan Gordon a green-hand on the hundred thousand-acre Montana G-G Ranch of his uncle Grant Gordon. Being the nephew of crotchety old Grant did not help young Dan with the old hands of the ranch. Through his friendship with Curly Bear, an Indian, Dan discovers a hidden passage to the top of a mesa called Rainrock. Here Dan discovers a fine herd of wild horses. Dan immediately picks out Pippin for his own. Breaking Pippin wore both Dan and Pippin to a frazzle. Horses save the G-G cattle ranch. Weather, wolves, terrain are essential features of the story as each presents Dan and the others a real challenge. Boys and girls will thoroughly enjoy this story of ranch and out-of-doors life.

CHIPPERFIELD, JOSEPH E. *Windruff of Links Tor.* New York: Longmans, Green and Company, 1951. 305 p. $3.00.

Windruff is the story of a shepherd dog who lived in the wild moors of western England. The Tors are granite remains now 1500 feet high, of once high mountains. Windruff as a small pup was adopted and raised by a fox Redbrush. Taught the cunning ways of the fox, Windruff became a magnificient creature. Tom Newsome came to Great Links Tor to search for Windruff. With great patience and understanding he finally won Windruff. This is an unusually appealing story of a dog that boys will love. Many terms of this book by an Englishman will be quite strange to American readers. Probably that will add even more zest to the reading of the book.

BARRINGTON, G. W. *Wind Runner.* New York: Longmans, Green and Company, 1951. 160 p. $2.50.

This is the delightful story of an African antelope. Boys and girls will enjoy this story of Fleet the Wind Runner. It tells the story of Fleet's life from the day he is born—a life of ever-present extreme danger, a fight for survival. His constant struggle against the forces of nature—the rigors of heat and drouth, the beasts of prey, makes for a story packed with suspense and adventure. For awhile the pet of a caravan, Fleet becomes both a symbol of trust and one of fear to the natives.

Altogether this is an unusually fine story of animal life written without any attempt at anthropomophism—which science teachers will especially appreciate. The reviewer recommends this as an excellent addition to the elementary science library, either as a story to be read or told by the teacher, and as supplementary reading for the pupils.

NOLAN, JEANNETTE COVERT. *LaSalle and the Grand Enterprise.* New York: Julian Messner, Inc., 1951. 178 p. $2.75.

This is the story of that renowned explorer Robert Cavelier de LaSalle. Friend of the Indians, LaSalle did reach the mouth of the Mississippi with whose exploration his name is forever linked. His dream of forming a permanent French settlement at the mouth of the Mississippi was not realized by him. Ultimately he was betrayed by his one-time friends and was murdered in ambush. This is another interesting biography by Hoosier born and reared Mrs. Nolan who also wrote *Florence Nightingale,*

Clara Barton, James Whitcomb Riley, The Little Giant: the *Story* of *Stephen A. Douglas* and *Abraham Lincoln,* and other biographies. She is an instructor at the Indianapolis, Indiana University, Extension Center.

BLYTON, ENID. *Five Go Adventuring Again.* New York: Thomas Y. Crowell Company, 1951. 207 p. $2.50.

Five Go Adventuring Again is a story of school life, summer vacation, and adventure that will delight boys and girls. A mystery story is woven around the attempt to get Georgina's ("George") father's very important scientific formula. George's three cousins, Timothy the dog, and the Secret Way, Rolland the tutor and spy, and the two pseudo-artists combine to make a story teen age boys and girls will enjoy.

SCHOOR, GENE. *The Jim Thorpe Story: America's Greatest Athlete.* New York: Julian Messner, Inc., 1951. 186 p. $2.75.

In this case the subtitle happens to be the exact truth. Jim Thorpe has been voted by sports authorities not only the greatest football player of the twentieth century but also the greatest athlete in all sports for the first half of the twentieth century. Jim Thorpe is described by sportswriter Jimmy Powers as the most fabulous athlete in history, by Bill Stern as the most spectacular sports figure of all time, and by Bill Corum as one of the great sports personalities of all time.

Jim Thorpe, Oklahoma Fox and Sac Indian, first gained fame as a football player at Carlisle. His feats as a football player (college and professional), baseball player (as professional player on New York Giants, Boston Braves, Cincinnati Reds, and Milwaukee Brewers), and Olympic field and track star have never been equalled. In the Olympics he won four firsts in both the pentathlon and decathlon, feats still not equalled. His Olympian laurels were unjustly taken from him on what many consider an unjust technicality.

Strong, stubborn, proud, unpredictable Jim Thorpe might have become one of the greatest baseball players of all time had he not been on McGraw's New York Giants—where a clash of two similar personalities never allowed Thorpe to show his possible greatness in baseball.

The author, a boxer at the University of Miami, Coral Gables, boxing coach at the University of Minnesota, and noted writer of sports and other stories, has written in *The Jim Thorpe Story* one of the most interesting stories one is likely to read.

JACKSON, C. PAUL. *Rose Bowl Line Backer.* New York: Thomas Y. Crowell Company, 1951. 184 p. $2.50.

This is the story of Al Kudef, Captain of the Michigan Football team, who wanted to excel as a star ball carrier rather than assume the responsibility of leadership as the team's captain. Bill Froman, the star ball carrier, had also wanted to be captain. Naturally, there was a clash of presonalities, that was not resolved until the second half of the Rose Bowl Game. This is a story most boys will enjoy, told by a writer who knows football, boys and young men.

KEITH, HAROLD. *A Pair of Captains.* New York: Thomas Y. Crowell Company, 1951. 160 p. $2.50.

A Pair of Captains is a story of high-school basketball, told with clarity, simplicity, descriptive accuracy, and detail. It also emphasizes the importance of team play, responsibility and having the respect of fellow students. Bee Smith and Eddie O'Brien will delight most teen-age boys interested in playing basket-ball.

BRYANT, CHESTER. *The Lost Kingdom.* New York: Julian Messner, Inc., 1951. 184 p. $2.75.

The Lost Kingdom is a delightful story of life in the jungle—both plant and animal. It is the story of Rodmika, a thirteen-year old Hindu boy, whose knowledge and love of animal life, makes this a memorable story reminiscent of *Kim* and *The Yearling* or *Bambi.* The scene is laid in India where Rodmika, reared in the American Foundation, shows that building a road thru a jungle swamp is quite possible although it had been considered quite impassable. Rodmika and his brother cross the jungle, find an old road crossing it, rescue an American boy visitor, and discover the ruins of a castle showing Rodmika himself is of royal ancient lineage. Interspersed with the story is much science about life in the teeming jungle. It is an excellent story for teen-agers.

JOHNSON, ENID. *Jerry's Treasure Hunt.* New York: Julian Messner, Inc., 1951. 64 p. $1.50.

When Jerry lived in the country they burned the papers and rags, buried the cans and bottles, and fed the scraps to animals. But when he went to live in the city, big trucks came to haul away the garbage. Jerry lost his stamp album and went to the city dump to find it.

This is a story of modern sanitation. The illustrations by Ursula Koering add charm and understanding to the thory. In reading difficulty the book is about fourth or fifth grade level.

WOOLEY, CATHERINE. *Schoolroom Zoo.* New York: William Morrow and Company, 1950. 191 p. $2.00

This is one of the *Morrow Junior Books.* Boys and girls of junior high school should enjoy reading this book. The story concerns

Ellie a third grade nature enthusiast who collects a "zoo" in her room much to the disgust of her sister Esther. Her zoo consists of Rocky the red eft, Mister the cat, Pete the dog, and a mouse. Later she brings a small garter snake to school, which is the beginning of the school "zoo"—again to the horror and disgust of a little girl named Lilac. On a nature trip Ellie finds she is afraid to walk across some planks high above a stream. Her realization of the way she feels about heights causes her to understand the fear reactions of her sister Esther and Lilac. Incidentally both of them do gradually overcome this fear.

This is an excellent elementary science book and grade teachers may be encouraged to develop their own classroom zoos or "nature corners."

PRESCOTT, JOHN BREWSTER. *The Beautiful Ship.* New York: Longmans, Green, and Co., 1952. 182 p. $2.50.

This is a fictional story of modern fishing in Lake Michigan. Eric faces problems of lessening supply of fish, piracy, storms, and sea lamprey. Boys will enjoy the story.

WYNDHAM, LEE. *Slipper Under Class.* New York: Longmans, Green and Co., 1952. 181 p. $2.50.

This is the story of Maggie Jones who so intensely desired and so faithfully and strenuously trained to be a classical ballet dancer only to find herself possessing unusual talent for comic ballet roles in the movies.

BUTTERFIELD, FRANCES W. *From Little Acorns: The Story of Your Body.* New York (1165 Broadway): Renbayle House, Publishers, 1951. 159 p. $2.50.

This is the story of the human body: its functions and operations. It is intended for boys and girls of ages 8 to 12. Much of the writing is in conversational style and is read or understood by children of the above age. Numerous illustrations by Dorothy M. Weiss add much to the general appeal of the book. The book discusses digestion, the teeth and framework of the body, respiration, circulation, nervous system, and reproduction. It seems to the reviewer to be an unusually fine book for children of this age level. It is a *different* physiology book.

OLDS, HELEN D. *Fisherman Jody.* New York: Julian Messner, Inc., 1951. 62 p. $1.50.

Fisherman Jody is a Messner *Everyday Adventure Story.* This is the story of ten-year old Jody's trip to sea with the fishing fleet. They went to the Grand Banks and brought the boat-loads of fish to the Fulton Fish Market in New York City. It is an interesting book on the activities and lives of men engaged in one of the world's oldest occupations. Illustrations by Jules Gotlieb add much to the attractiveness of the book. It is a recommended book for the fourth or fifth grade.

TOOZE, RUTH. *Tim and the Brass Buttons.* New York: Julian Messner, Inc., 1951. 63 p. $1.50.

Tim and the Brass Buttons is primarily a story that teaches rules of safety, shows that policemen are really friends, and proves some things cannot be bought—they must be earned. There are appealing illustrations by Zhenya Gay. The book is suitable for second and third grade children.

GRETOR, ESTHER. *Kippie the Cow.* New York: Julian Messner, Inc., 1951. 28 p. $2.00.

This is an amusing story of what happened when Farmer Marsden tried to sell Kippie the Cow at the fair. Primary children will enjoy having the story read to them or intermediate grade children will enjoy reading it themselves. Illustrations in red add zest to the story. The story is translated from the Danish by Kurt Singer.

EBERLE, IRMENGARDE. *Hop, Skip, and Fly.* New York: Holiday House Inc., 1951. 62 p. $2.00.

Hop, Skip, and Fly is the story of small creatures—the life of the frog, scorpion, brown bat, stickleback, garter snake, and lizard. Children of third grade to fifth grade level will enjoy the book. The stories are easy to read and the content seems to be scientifically accurate. The book has been highly recommended by Junior Natural History Magazine, Library Journal, Horn Book, the New York Times and May Hill Arbuthnot of *Children and Books.* The author makes the following interesting comment:

> I should like you to know why I let the animals in these stories talk. It wasn't done to make them seem more amusing and likeable than they are. It was done to translate their unspoken language into our spoken language.
>
> You will see that these animals talk only about the things that have to do with their natural impulses and feelings—the need for food, the bringing to life of the young, the fear of harm, the wish for safety, the need for sleep, the pleasure in growing—all these are feelings and impulses that people have too.
>
> When we put these things into our own spoken words it is easier to understand and get to know, the animal, just as it is easier to understand people who speak our own language instead of some language that we have never learned.